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IMPACT OF THE TELECOMMUNICATIONS ACT OF 1996 AND SPECTRUM ALLOCATION ON CELLULAR TELEPHONE TECHNOLOGY

by

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September 2003

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From 1983, when the first cellular network was established, to 1992, the wireless industry grew by ten million customers. From 1993 to 2000, the wireless industry grew by 90 million customers. Today, there are more than 149 million U.S. wireless subscribers. The phenomenal growth of the wireless industry can be traced to several factors. These factors are improvements in cellular technology, expansion of that technology and the allocation of spectrum by the federal government.

This thesis analyzes the correlation between the Telecommunications Act of 1996 (the Act) and the rapid expansion of cellular technology that occurred after the Act became law. It also analyzes the impact of spectrum management and allocation on the evolution of cellular technology. To demonstrate how cellular technology has evolved over time, the history, standards, and generations of cellular technology will be reviewed. Research findings will be shown that validate the Act's impact on the expansion of cellular technology. Finally, the impact of spectrum management and allocation on the evolution of cellular technology in the United States, specifically in terms of implementation of third generation (3G) technology, will be shown by analyzing the policies of the government organizations responsible for managing the frequency spectrum.

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IMPACT OF THE TELECOMMUNICATIONS ACT OF 1996 AND SPECTRUM ALLOCATION ON CELLULAR TELEPHONE TECHNOLOGY

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ABSTRACT

From 1983, when the first cellular network was established, to 1992, the wireless industry grew by ten million customers. From 1993 to 2000, the wireless industry grew by 90 million customers. Today, there are more than 149 million U.S. wireless subscribers. The phenomenal growth of the wireless industry can be traced to several factors. These factors are improvements in cellular technology, expansion of that technology and the allocation of spectrum by the federal government.

This thesis analyzes the correlation between the Telecommunications Act of 1996 (the Act) and the rapid expansion of cellular technology that occurred after the Act became law. It also analyzes the impact of spectrum management and allocation on the evolution of cellular technology. To demonstrate how cellular technology has evolved over time, the history, standards, and generations of cellular technology will be reviewed. Research findings will be shown that validate the Act's impact on the expansion of cellular technology. Finally, the impact of spectrum management and allocation on the evolution of cellular technology in the United States, specifically in terms of implementation of third generation (3G) technology, will be shown by analyzing the policies of the government organizations responsible for managing the frequency spectrum.

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I. INTRODUCTION

A. PURPOSE OF THE STUDY

In 1983, the United States' first analog cellular mobile telephone system was launched in Chicago. From 1983 to 1992, the wireless industry grew by ten million customers. From 1993 to 2000, the wireless industry grew by 90 million customers. As of September 7, 2003, there were 149,511,544 current United States wireless subscribers, more than 50 percent of the United States population.[1] The phenomenal growth of the wireless industry can be traced to several factors. These factors are improvements in cellular technology, expansion of service areas and the allocation of spectrum by the federal government.

The purpose of this thesis is twofold. First, it will demonstrate the correlation between the Telecommunications Act of 1996 (the Act) and the expansion of cellular technology in the United States. Then, it will analyze the impact of spectrum management and allocation on the evolution of cellular technology. To demonstrate how cellular technology has evolved over time, the history, standards, and generations of cellular technology will be reviewed. Research findings will be shown that validate the Act's impact on the expansion of cellular technology. Finally, the impact of spectrum management and allocation on the evolution of cellular technology in the United States, specifically in terms of implementation of third generation (3G) technology, will be shown by analyzing the

[1] Cellular Telecommunications & Internet Association Home Page, 7 September 2003, <http://www.wow-com.com/consumer/faq/articles.cfm?ID=101>.

policies of the government organizations responsible for managing the frequency spectrum.

B. MILITARY RELEVANCE

The primary benefits of this research lie in the value of the information and analysis to both military and non-military practitioners in the computer science and information technology fields. The study is of particular use to service members in the Computer and Information Systems (Marine Corps terminology) Military Occupational Specialty (MOS) and related fields as they evaluate telecommunications systems to be acquired and implemented based on current regulations and technology available.

The discussions of second and third generation cellular technologies are particularly relevant due to the constant evolution occurring in these areas. Professionals in the computer science and information management realms (i.e., Communication and Information Systems Officers) must certainly stay abreast of the changes in the telecommunications industry. For instance, their knowledge of the telecommunications industry relates to their ability to provide seamless communications services and accurate government contract advisement.

C. RESEARCH QUESTIONS

This thesis study provides answers or partial answers for the following primary questions:

- What impact has the Telecommunications Act of 1996 had on the expansion of cellular service in the United States?
- What impact has spectrum allocation policy and management in the United States had on the evolution of cellular service to 3G technology?

There are also several secondary questions that provide background for and support conclusions for the primary questions previously listed:

- What is the history of cellular technology in the United States and how has it evolved through the years?
- What are the standards and generations of cellular technology used in the United States?
- What government agencies are responsible for spectrum management and allocation?
- What is the history of spectrum policy and how has it changed over time?
- What is the current state of allocation for cellular service?

D. GOALS OF THE THESIS

The goals of this thesis include the following:

- A review of the history of cellular telephone technology in the United States.
- A description of the transmitting interface standards used in the United States to provide cellular telephone service.
- A description of the different generations of cellular telephone technology.
- A review of the key provisions of the Telecommunications Act of 1996.
- An examination of the sections of the Telecommunications Act of 1996 that directly impacted the expansion of cellular service within the United States.
- A review of the government organizations tasked with managing and allocating spectrum in the United States.
- An examination of spectrum policy in the United States.
- An examination of the spectrum allocated for cellular, PCS, and 3G wireless services.
- Recommendations for improving spectrum management and allocation policy to facilitate the evolution to 3G technology.

E. THESIS ORGANIZATION

The remainder of the thesis is organized into the following chapters:

- Chapter II – History of Cellular Telephone Technology in the United States. This chapter summarizes the history of cellular telephone technology in the United States.
- Chapter III – Standards and Generations of Cellular Systems in the United States. Describes the five different cellular transmitting interface standards currently used in the United States and summarizes the different generations of cellular technology.
- Chapter IV – Impact of the Telecommunications Act of 1996 on Cellular Expansion in the United States. Examines the direct impact of the Act on the expansion of cellular service and related issues.
- Chapter V – Impact of Spectrum Allocation on Cellular Evolution in the United States. Describes the impact of federal spectrum management and allocation policy on the evolution of cellular service in the United States to 3G technology.
- Chapter VI – Conclusion and Recommendations. Provides a final summary and gives recommendations for improving spectrum management and allocation policy to facilitate the evolution to 3G technology.

II. HISTORY OF CELLULAR TELEPHONE TECHNOLOGY IN THE UNITED STATES

A. INTRODUCTION

In order to fully understand the impact of the Telecommunications Act of 1996 and spectrum allocation on cellular telephone technology, it is helpful to review the history of this technology and how it has arrived at its current state. Cellular telephone technology is just one type of radio communication in use today. Other examples of radio communication applications include paging, amateur radio, dispatch, citizens band (CB), public service, cordless phones, and terrestrial microwave radio systems. The focus of this chapter will be on the development and evolution of the cellular telephone within the United States.

B. MOBILE TELPHONE SERVICE BEFORE CELLULAR

The origins of the mobile telephone can be traced back to two significant technological achievements, the invention of the telephone by Alexander Graham Bell in 1876 and the invention of the radio by Nikolai Tesla in the 1880s. Eventually, telephone and radio technology would converge and the concept of mobile radiotelephone communications became a viable reality.

The need to increase public safety was a key factor that contributed to the development of mobile telephone technology in the United States. In 1921, the Detroit, Michigan police department began to experiment with a radiotelephone system in their police cars. This system operated at 2 MHz, just above the present day *Amplitude Modulation (AM)* radio broadcast band, used Morse Code for signaling, and was one-way only. The patrolmen would have to stop at a wire-line telephone and call back to their station house after being sent a message over the system. In 1928, the system evolved to voice-based but was still one-way only. In March, 1933, the Bayonne, New Jersey, police department began using two-way communications and this was a dramatic improvement on the one-way system that the Detroit police department was using. By 1934, 192 municipal police radio systems and 58 state police stations had adopted AM mobile communications systems for public use in the United States.

In 1935, *Frequency Modulation (FM)* was developed by Edwin Howard Armstrong to improve radio broadcasting. FM has a larger bandwidth so it can carry a higher fidelity signal than AM. This technology reduced the required bulk of radio equipment and improved transmission quality. These two developments would have a substantial impact on mobile radiotelephone development.

The United States' involvement in World War II created an urgent need for FM technology to take the place of AM technology for higher quality, two-way mobile radio communications on the battlefield. The strategic value of wireless communication on the battlefield spurred companies like AT&T, Motorola and General Electric to focus on refining mobile and portable communications. Motorola's FM Handie-Talkie and Walkie-Talkie figured prominently among the products developed during the war years and carried over into peacetime use.[2]

[2] Cellular Telecommunications & Internet Association, "The History of Wireless, Frequently Asked Questions & Fast Facts," 24 Aug 2003 < http://www.wow-com.com/consumer/faq/articles.cfm?ID=101>

In 1946, the first public mobile telephone service was introduced in twenty-five major American cities. Each system used a single, high-powered transmitter and large tower in order to cover distances of over 50 km in a particular market. This early radiotelephone service was a FM push-to-talk system that used 120 kHz of Radio Frequency (RF) bandwidth in a half-duplex mode. The large amount of RF bandwidth was needed because it was difficult to mass-produce tight RF filters and low-noise, front-end receiver amplifiers.[3]

In the 1950s, the Federal Communications Commission (FCC) doubled the number of mobile telephone channels per market, but did not allocate any new spectrum; and technology improvement led to the reduction of channel bandwidth to 60 kHz. In the 1960s, FM channel bandwidth was further reduced to 30 kHz. Also, in the 1950s and 1960s, automatic channel trunking was introduced and implemented under the label Improved Mobile Telephone Service (IMTS). Channel trunking permits a large number of users to share a relatively small number of communication paths - or trunks. With IMTS, telephone companies began offering full duplex, auto dial, auto-trunking phone systems.[4] IMTS quickly became saturated because it did not have the capacity to handle the amount of demand. There was a waiting list of over 3,700 people, and service was poor due to call blocking and usage over the few channels.[5]

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[3] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 4.

[4] Calhoun, G., *Digital Cellular Radio*, Norwood, MA: Artech House, 1988.

[5] Calhoun.

C. THE EVOLUTION OF CELLULAR

Faced with an ever increasing demand for mobile phone service and a lack of spectrum allocation by the FCC, research efforts focused on restructuring the radiotelephone system to achieve high capacity with limited radio spectrum while at the same time covering large areas. During the 1950s and 1960s, AT&T Bell Laboratories and other telecommunications companies throughout the world developed the theory and techniques of cellular radiotelephony – the concept of breaking a coverage zone (market) into small cells, each of which reuse portions of the spectrum to increase spectrum usage at the expense of greater system infrastructure.[6]

The cellular concept is a system–level idea which calls for replacing a single, high power transmitter (1 very large cell) with many low power transmitters (small cells), each providing coverage to only a small portion of a service area. Each transmitter, or base station, is allocated a portion of the total number of channels available to the entire system, and nearby base stations are assigned different groups of channels so that all the available channels are assigned to a relatively small number of neighboring base stations. Neighboring base stations are assigned different groups of channels so that the interference between base stations (and the mobile users under their control) is minimized.[7] Base stations and their channel groups are systematically spaced throughout a market. This ensures the available channels are

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[6] MacDonald, V.H., "The Cellular Concept," *Bell System Technical Journal*, Vol. 58, No. 1, January 1979: 15-43.

[7] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 57-58.

distributed throughout the geographic region and can be reused as many times as necessary as long as the interference between co-channel stations is kept below acceptable levels. As the demand for service increases, the number of base stations may be increased to provide additional radio capacity with no additional increase in radio spectrum.

Cellular radio systems rely on an intelligent allocation and reuse of channels throughout a coverage region.[8] Each cellular base station is allocated a group of radio channels to be used within a small geographic area called a cell. Base stations in adjacent cells are assigned channel groups which contain completely different channels than neighboring cells. The base station antennas are designed to achieve the desired coverage within the particular cell. By limiting the coverage area to within the boundaries of a cell, the same group of channels may be used to cover different cells that are separated from one another by distances large enough to keep interference levels within tolerable limits.[9] The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called *frequency reuse* or *frequency planning*.[10] Figure 1 below illustrates the concept of frequency reuse. Cells with the same letter use the same letter use the same set of frequencies. A

[8] Oeting, J., "Cellular Mobile Radio — An Emerging Technology," *IEEE Communications Magazine*, November 1983: 10-15.

[9] Rappaport, T.S., *Wireless Communications - Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 58.

[10] MacDonald, V.H., "The Cellular Concept," *Bell System Technical Journal*, Vol. 58, No. 1, January 1979: 15-43.

cell cluster is outlined in bold and replicated over the coverage area.[11]

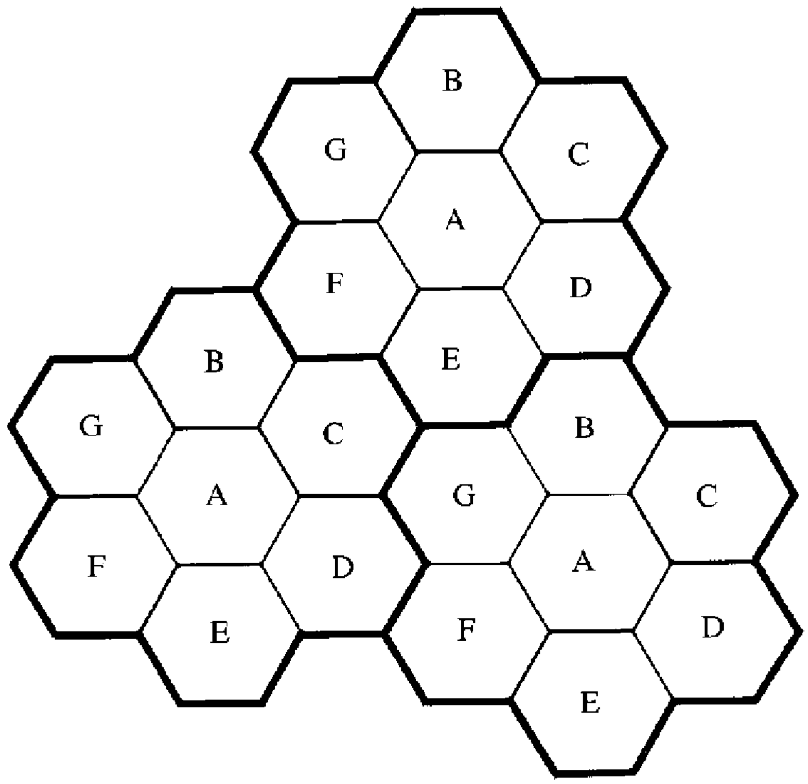

Figure 1. Frequency Reuse (From: Rappaport)[12]

AT&T proposed the concept of a cellular mobile telephone system to the FCC in 1968, although technology was not available to implement a fully functional cellular telephony system until 1978. In 1983, the FCC finally allocated 666 duplex channels (40 MHz of spectrum in the 800 MHz band, each channel having a one-way bandwidth of 30 kHz for total spectrum occupancy of 60 kHz for each duplex channel) for the U.S. Advanced Mobile Phone System (AMPS).[13]

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[11] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 59.

[12] Rappaport.

[13] Young, W.R., "Advanced Mobile Phone Service: Introduction, Background, and Objectives," *Bell Systems Technical Journal*, Vol. 58,

AMPS will be discussed in further detail in the next chapter. According to FCC rules, each city (called a market) was only allowed to have two cellular radio system providers, thus providing a duopoly within each market which would assure some level of competition.[14] The allocated channels in each market were split equally between the two carriers. After the Federal Communications Commission (FCC) declared in 1987 that cellular licensees could employ alternative cellular technologies in the 800 MHz band, the cellular industry began to research new transmission technology as an alternative to AMPS.[15]

In 1988, the Cellular Technology Industry Association (CTIA) was established to work with the cellular service operators and researchers to identify new technology requirements and set goals. They wanted the new products and services introduced by 1991, a 1000% percent increase in system capacity with both AMPS (analog) and digital capability during transmission, and new data features such as fax and messaging services. The Telecommunications Industry Association (TIA) created a standard specification based on the requirements the CTIA had recommended.[16] In 1989, the FCC granted an additional 166 channels (10 MHz) to U.S. cellular service providers to accommodate the rapid growth and demand for cellular service.

No. 1, January 1979: 1-14.

[14] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 4.

[15] Bellis, M., "Selling the Cell Phone – Part 2: Wireless PCS Technology," *Inventors*, 24 August 2003 <http://inventors.about.com /ibrary/weekly/aa072199.htm>.

[16] Bellis.

In late 1991, the first U.S. Digital Cellular (USDC) system hardware was installed in major U.S. cities. The USDC standard, also known as the TDMA Interim Standard 54 or TDMA IS-54 and later as IS-136, was developed by the TIA and released in early 1991. This standard used *time division multiple access (TDMA)* and allowed cellular operators to gradually replace some single-user analog channels with digital channels that supported three users in the same 30 kHz bandwidth.[17] The TDMA standard will be discussed further in the next chapter.

A cellular system based on *code division multiple access (CDMA)* was developed and commercially introduced by Qualcomm, Inc. in 1995. It was later standardized by the TIA as an Interim Standard (IS-95). This system supports a variable number of users in 1.25 MHz wide channels using *direct sequence spread spectrum*. The first CDMA networks were commercially launched in 1995, and provided roughly 10 times more capacity than analog networks. CDMA will be discussed in greater detail in the next chapter.

In the early 1990s, a newly specialized mobile radio service (SMR) was developed to compete with U.S. cellular radio carriers.[18] By purchasing small groups of radio system licenses from a large number of independent private radio service providers throughout the country, Nextel and Motorola formed an extended SMR (E-SMR) networking the 800 MHz band that provides capacity and services similar to cellular. Using Motorola's integrated radio system (MIRS),

[17] EIA/TIA Interim Standard, "Cellular System Dual Mode Mobile Station-Land Station Compatibility Specifications, IS-54," *Electronic Industries Association*, May 1990.

[18] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 6.

SMR integrates voice dispatch, cellular phone service, messaging, and data transmission capabilities on the same network.[19] In 1994, Motorola replaced MIRS with the *integrated digital enhanced network (iDEN)*. iDEN will be discussed in greater detail in the next chapter.

Also in 1994, the FCC announced it was allocating spectrum specifically for *Personal Communications Service (PCS)* technologies at the 1900 MHz band. PCS licenses were auctioned by the FCC to wireless providers in early 1995. These licenses have spawned new wireless services that complement, as well as compete with, cellular and SMR.[20] Essentially, PCS systems operate on a different radio frequency (the 1.9 GHz band) than traditional cellular networks and generally use all digital technology for transmission and reception. One of the stipulations of the PCS license was that a majority of the coverage area be operational before the year 2000. As many as five PCS licenses were allocated for each major U.S. city.

D. THE FUTURE OF CELLULAR TECHNOLOGY

It is generally accepted that cellular telephone technology has evolved through three generations. These three generations are referred to as first generation (1G), second generation (2G), and third generation (3G). The technology prior to first generation was not technically cellular. This early radiotelephone service was FM push-to-talk, operated in half-duplex mode and used single, high-powered transmitters. The next chapter will examine

[19] Filiey, G.B. and Poulsen, P.B., "MIRS Technology: On the Fast Track to Making the Virtual Office a Reality," *Communications*, January 1995: 34-39.

[20] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 6.

the different generations of cellular telephone technology in greater detail.

Currently, cellular technology in the United States is primarily 2G. Voice service is the overwhelmingly dominant function used by cellular subscribers. Wireless data capability is seldom used but that is slowly changing.

Cellular carriers are currently retrofitting and modifying their 2G digital networks with step phased packet switched technology improvements to enable increases to wireless data performance and always on connections. These phased evolutions are part of a planning roadmap to a 3G level of performance. 3G is a global initiative of the International Telecommunications Union (IMT-2000) and will be based on high-speed wireless packet data transmitting technology that will provide real-time, always connected multimedia applications with streaming audio and video. The major obstacle to implementation of 3G in the U.S. is the lack of available spectrum to implement it. This topic will be discussed in depth in a later chapter.

E. SUMMARY

From its beginnings as a way to improve public safety to its widespread use by the public today, cellular telephone technology has undergone an incredible transformation in the United States, from both an acceptance point of view and evolutionary point of view. From 1983 to 1992, the wireless industry grew by ten million customers. This time frame coincides with the implementation of analog AMPS in 1983 to the beginnings of the shift to digital cellular networks in late 1991. From 1993 to 2000, the wireless industry grew by 90 million customers. Here again, it is easy to see that as the networks continued to improve with TDMA, CDMA, and iDEN the number of customers kept increasing. Today, there are more than 149 million U.S. wireless subscribers, more than 50 percent of the United States population. As of September 7, 2003, there were 149,511,544 current United States wireless subscribers.[21]

[21]Cellular Telecommunications & Internet Association Home Page, 7 September 2003 <http://www.wow-com.com/consumer/faq/articles.cfm?ID=101>.

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III. STANDARDS AND GENERATIONS OF CELLULAR SYSTEMS IN THE UNITED STATES

A. INTRODUCTION

The previous chapter made reference to the different standards and generations of cellular systems that are currently in use in the United States. This chapter will go into greater detail in regards to both of these topics. In wireless communication systems, it is usually desirable to allow the users to simultaneously send information to the base station while receiving information from the base station. In conventional telephone systems, it is possible to talk and listen simultaneously, and this effect, called duplexing, is also required in wireless communication. Duplexing can be achieved via two different techniques utilizing either frequency or time. Frequency division duplexing (FDD) provides two different bands of frequencies for each user, and time division duplexing (TDD) uses time to provide both forward and reverse link. The duplexing techniques are usually described along with particular multiple access schemes. Multiple access schemes are used to allow many users to share a finite amount of bandwidth.

There are currently five different cellular standards that compete in the U.S. for subscribers: Analog (or FDMA), TDMA, GSM, CDMA and iDEN. In reality, these standards are the multiple access schemes described above. More specifically, frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (CDMA) are the three major multiple access schemes used to share the available bandwidth in cellular communication systems. GSM and iDEN primarily use the TDMA scheme, with a few different parameters added.

These five standards fall under the categories of first and second generation technologies. Analog is the primary first generation technology that will be examined. TDMA, GSM, CDMA and iDEN are all second generation technologies and will each be discussed individually. Third generation technologies are currently emerging and are based on the evolution of second generation technologies. The discussion of third generation technology will focus on the proposed standards and their capabilities. The evolution from second generation to third generation has led to interim technologies known as 2.5G. These interim technologies will also be examined.

B. FIRST GENERATION (1G) CELLULAR TECHNOLOGY

The first generation of cellular wireless communications was based on analog technology and progressively became available to the consumer during the late 1970s and early 1980s. Since the early 1980s, the most common first generation system in North America has been the Advanced Mobile Phone Service (AMPS).[22] Table 1 lists the parameters for the AMPS standard.

1. Spectral Allocation

As shown in Table 1, two 25-MHz bands are allocated to AMPS, one for transmission from the base station to the mobile unit (869-894 MHz), the other for transmission from the mobile to the base station (824-849 MHz). In order to encourage competition, each of these bands is split in two.

[22] Stallings, W., *Wireless Communications and Networks*, Upper Saddle River, NJ: Prentice Hall, 2002: 303.

Base Station Transmission Band	869 to 894 MHz
Mobile Unit Transmission Band	824 to 849 MHz
Spacing between forward and reverse channels	45 MHz
Channel Bandwidth	30 kHz
Number of full-duplex voice channels	790
Number of full-duplex control channels	42
Mobile unit maximum power	3 watts
Cell size, radius	2 to 20 km
Modulation, voice channel	FM, 12-kHz peak deviation
Modulation, control channel	FSK, 8-kHz peak deviation
Data transmission rate	10 kbps
Error control coding	BCH (48,36,5) and (40,28,5)

Table 1. AMPS Parameters (From: Stallings)[23]

This procedure follows from the FCC rule that was mentioned in the previous chapter. An operator is allocated 12.5 MHz in each direction for its system. The channels are spaced 30 kHz apart, allowing 416 channels per operator. Of these 416 channels, 21 are allocated for control and 395 carry calls. The control channels are data channels operating at 10 kbps. The conversation channels carry the conversations in analog using frequency modulation. The conversation channels also carry control information in bursts as data. Because the number of channels is inadequate for most major markets, AMPS relies heavily on frequency reuse to increase capacity.[24] Frequency reuse is discussed in the previous chapter.

[23] Stallings, 304.

[24] Stallings, 303.

2. AMPS Control Channels

The 21 control channels, that are a part of each AMPS system, are full-duplex and 30 kHz, i.e. there are 21 reverse control channels (RCCs) from subscriber to base station and 21 forward control channels (FCCs) from base station to subscriber. The data on these channels is digital and transmitted in frames using Frequency Shift Keying (FSK). Control information can also be transmitted over a voice channel during a conversation. The mobile unit, or base station, inserts a burst of data by turning off the voice FM transmission for about 100 ms and replacing it with an FSK-encoded message. These messages are used to exchange urgent messages, such as change power level and handoff.[25]

3. Frequency Division Multiple Access (FDMA)

Frequency division multiple access (FDMA) is used by AMPS to assign individual channels to individual users. Each user is allocated a unique frequency band or channel and during the period of the call, no other user can share the same channel. FDMA has the following features:

- An FDMA channel carries only one phone circuit at a time.
- If an FDMA channel is not in use, then it sits idle and can't be used by other users to increase or share capacity.
- After a voice channel has been assigned, the base station and mobile transmit simultaneously and continuously.
- FDMA channels have a narrow bandwidth (30 kHz in AMPS) and each channel supports only one circuit per carrier.
- FDMA systems have a lower complexity than TDMA systems.
- FDMA requires fewer overhead bits because of its continuous transmission scheme.

[25] Stallings, 305.

- FDMA systems have higher cell site system costs when compared with TDMA systems.
- FDMA mobile units require the use of duplexers since both receiver and transmitter operate concurrently.
- FDMA requires tight RF filtering to minimize adjacent channel interference.

C. SECOND GENERATION (2G) CELLULAR TECHNOLOGY

First-generation cellular networks, such as AMPS, quickly became highly popular.[26] However, the service on these networks was poor and their capacity was limited. Second generation cellular networks offer higher-quality signals, higher data rates for support of digital services, and greater capacity. Some of the key differences between 1G and 2G are listed below:

- Digital traffic channels: First generation systems are almost purely analog, whereas second generation system are digital.
- Encryption: Second generation systems encrypt all traffic, whereas first generation systems provide no security.
- Error detection and correction: Second generation systems use error detection and correction techniques to provide clear voice reception.
- Channel access: In first generation systems, each cell supports a number of channels and only one user is allocated a certain channel at any given time. Second generation systems also provide multiple channels per cell, but each channel is dynamically shared by a number of users using TDMA or CDMA.

The three main second generation cellular network standards in use in the United States are Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), and the Global System for Mobile Communication (GSM). iDEN is also used in the United States but to a lesser extent than the other three. GSM and iDEN are

[26] Stallings, 305.

specific types of TDMA systems. Table 2 lists the main implementations of CDMA, via IS-95, and TDMA, via GSM and the IS-136, systems and their characteristics.

1. Time Division Multiple Access (TDMA)

Time division multiple access (TDMA) systems divide the available radio spectrum into time slots. Only one user is permitted to either transmit or receive in each of these time slots. The time slots cyclically repeat, therefore a channel can be thought of as a particular time slot that re-occurs every frame, where *N* time slots comprise a frame. TDMA systems transmit data in a buffer-and-burst method, thus the transmission for any user is non-continuous.[27] IS-136 is the most commonly used TDMA scheme in North America.[28] The key features of TDMA are listed below:

- TDMA shares a single carrier frequency with several users, where each user makes use of non-overlapping time slots. The number of time slots per frame depends on several factors, such as modulation technique, available bandwidth, etc.
- Since data transmission occurs in bursts, this allows the subscriber transmitter to be turned off when not in use. This leads to a lower amount of battery consumption.
- The handoff process is simpler for a subscriber unit with TDMA because of noncontinuous transmission.
- TDMA uses different time slots for transmission and reception, therefore duplexers are not required.
- Due to high transmission rates with TDMA, adaptive equalization is usually required.
- High synchronization overhead is required in TDMA systems because of burst transmissions.

27 Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 453.

28 Rappaport, 453.

2G Cellular Telephone Systems	GSM	IS-136	IS-95
Year introduced	1990	1991	1993
Access method	TDMA	TDMA	CDMA
Base station transmission band	935 to 960 MHz	869 to 894 MHz	869 to 894 MHz
Mobile station transmission band	890 to 915 MHz	824 to 869 MHz	824 to 869 MHz
Spacing between forward and reverse channels	45 MHz	45 MHz	45 MHz
Channel bandwidth	200 kHz	30 kHz	1250 kHz
Number of duplex channels	125	832	20
Mobile unit maximum power	20 W	3 W	0.2 W
Users per channel	8	3	35
Modulation	GMSK	Π/4 DQPSK	QPSK
Carrier bit rate	270.8 kbps	48.6 kbps	9.6 kbps
Speech coder	RPE-LTP	VSELP	QCELP
Speech coding bit rate	13 kbps	8 kbps	8,4,2,1 kbps
Frame size	4.6 ms	40 ms	20 ms
Error control coding	Convolutional 1/2 rate	Convolutional 1/2 rate	Convolutional 1/2 rate forward, 1/3 rate reverse

Table 2. Second Generation Cellular Telephone Systems (From: Rappaport)[29]

- An advantage of TDMA is that it is possible to allocate different numbers of time slots per frame to different users. This allows bandwidth to be supplied on demand to different users by concatenating or reassigning time slots based on priority.

2. Code Division Multiple Access (CDMA)

Code division multiple access (CDMA) is a spread spectrum-based technique for multiplexing that provides an alternative to TDMA for second-generation cellular

[29] Rappaport, 308.

networks.[30] CDMA functions through multiplying the narrowband message signal by a very large bandwidth signal called the spreading signal. The spreading signal is a pseudo-noise code sequence (PN) that has a chip rate which is orders of magnitude greater than the data rate of the message. All users in a CDMA system use the same carrier frequency and may transmit simultaneously. Each user has its own pseudorandom code word which is approximately orthogonal to all other code words. The receiver performs a time correlation operation to detect only the specific desired code word. All other code words appear as noise due to decorrelation. For detection of the message signal, the receiver needs to know the code word used by the transmitter. Each user operates independently with no knowledge of other users.[31] IS-95 is the most widely used CDMA scheme and is primarily deployed in North America. CDMA has the following features:

- The same frequency is shared by many users on a CDMA system.
- Unlike FDMA and TDMA, CDMA has a soft capacity limit. As users increase, the noise floor increases lineally. CDMA has no absolute user limit, but system performance degrades as users increase and improves as they decrease.
- Multipath fading may be substantially reduced because the signal is spread over a large spectrum.
- CDMA has very high channel data rates.
- Through the use of co-channel cells, CDMA can use macroscopic spatial diversity to provide soft handoff.
- CDMA suffers from both self-jamming and the near-far problem. Self-jamming arises from the fact that the PN

[30] Stallings, W., *Wireless Communications and Networks*, Upper Saddle River, NJ: Prentice Hall, 2002: 320.

[31] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 458.

sequences of different users are correlated after long delays which are caused by multiple reflections. In general, the near-far problem occurs when the strongest received mobile signal captures the demodulator at the base station. This decreases the probability that weaker signals will be received.

3. Global System for Mobile Communication (GSM)

Global System for Mobile Communication (GSM) was developed in Europe to provide a common second generation cellular technology so that the subscriber units could be used throughout the continent.[32] GSM technology has been extremely successful and is an extremely popular standard, worldwide, for new implementations. According to the latest subscriber statistics released by the GSM Association, there are 863.6 million GSM subscribers world wide, with the preponderance of these located mainly in Europe and Asia Pacific.[33] The number of GSM subscribers in North America is approximately 21.9 million.

In GSM, the radio channels are based on a TDMA structure that is implemented on multiple frequency subbands (TDMA/FDMA). Each base station is equipped with a certain number of these preassigned frequency/time channels.[34] The GSM spectral allocation is 25 MHz each for base station and mobile transmission. Radio frequency carriers are spaced every 200 kHz, which provides 124 full-duplex channels. There are two types of channels, traffic and control. GSM uses a complex hierarchy of TDMA frames to define logical channels. Fundamentally, each 200 kHz

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[32] Stallings, W., *Wireless Communications and Networks*, Upper Saddle River, NJ: Prentice Hall, 2002: 312.

[33] GSM World, "GSM Subscriber Statistics," 29 Aug 2003 <http://www.gsmworld.com/news/statistics/substats.shtml>.

[34] Rahnema, M., "Overview of the GSM system and protocol architecture," *IEEE Communications Magazine*, Vol. 31, No. 4, April 1993: 92-100.

frequency band is divided into 8 logical channels defined by the repetitive occurrence of time slots.[35]

4. Integrated Digital Enhanced Network (iDEN)

The Integrated Digital Enhanced Network (iDEN) was introduced by Motorola in 1994. iDEN combines the capabilities of a digital cellular telephone, two-way radio, alphanumeric pager, and data/fax modem in a single network. iDEN operates in the 800 MHz, 900 MHz, and 1.5 GHz bands and is based on TDMA and GSM architecture. It uses Motorola's Vector Sum Excited Linear Predictors (VSELP) vocoder for voice compression and quadrature amplitude modulation (QAM) modulation to deliver 64 kbps over a 25 kHz channel.[36] Nextel Communications is currently the largest domestic carrier that uses iDEN technology as the backbone of its nationwide wireless network. As of Q2/FY2003, there are approximately 11.7 million subscribers in the U.S. that utilize Nextel's iDEN based network.[37]

5. Personal Communications Service (PCS)

PCS is a new generation of wireless-phone technology that introduces a range of features and services surpassing those available in analog- and digital-cellular phone systems. PCS provides the user with an all-in-one wireless phone, paging, messaging, and data service having a greatly improved battery-standby time.[38] PCS operates in the 1850

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[35] Stallings, W., *Wireless Communications and Networks*, Upper Saddle River, NJ: Prentice Hall, 2002: 315.

[36] SearchNetworking.com Definitions, "iDEN," 29 Aug 2003, <http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci511679,00.html>.

[37] International Engineering Consortium, "Personal Communications Service Tutorial," *IEC On-Line Education*, 29 Aug 2003, <http://www.iec.org/online/tutorials/pcs/index.html>.

[38] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 522.

MHz to 1990 MHz band and is based on CDMA or GSM technology. Whether CDMA or GSM technology is used is based on the PCS provider. PCS and *personal communications networks (PCNs)* are commonly associated with the concept of global wireless communications and third generation (3G) cellular technology.

D. 2.5G CELLULAR TECHNOLOGY

The 2G digital standards that have been widely deployed since the mid-1990s were designed before the widespread use of the Internet. Consequently, 2G technologies use circuit-switched data modems that limit data users to a single circuit-switched voice channel. Data transmissions in 2G are approximately the same, less than 20 kbps, as the throughput rate for speech coded voice data in all 2G standards.[39]

Despite small user data rates, 2G standards are able to support limited Internet browsing and sophisticated short messaging capabilities using a circuit switched approach. In an effort to retrofit the 2G standards for compatibility with increased throughput data rates that are required to support modern Internet applications, new data-centric standards have been developed that can be overlaid upon existing 2G technologies. These new standards are known as 2.5G technology and allow existing 2G equipment to be modified and supplemented with new base station add-ons and subscriber unit software upgrades to support higher data rate transmissions for web browsing, e-mail traffic, mobile commerce, and location-based mobile services.[40]

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[39] Rappaport, 29.

[40] Rappaport, 29.

The appropriate 2.5G upgrade path for a particular wireless carrier must match the original 2G technology choice made earlier by the same carrier. For this reason, a wide range of 2.5G standards have been developed to allow each of the major 2G technologies (GSM, CDMA, and IS-136[TDMA]) to be upgraded incrementally for faster Internet data rates.[41] Figure 2 illustrates the various 2.5G and 3G upgrade paths for the major 2G technologies.

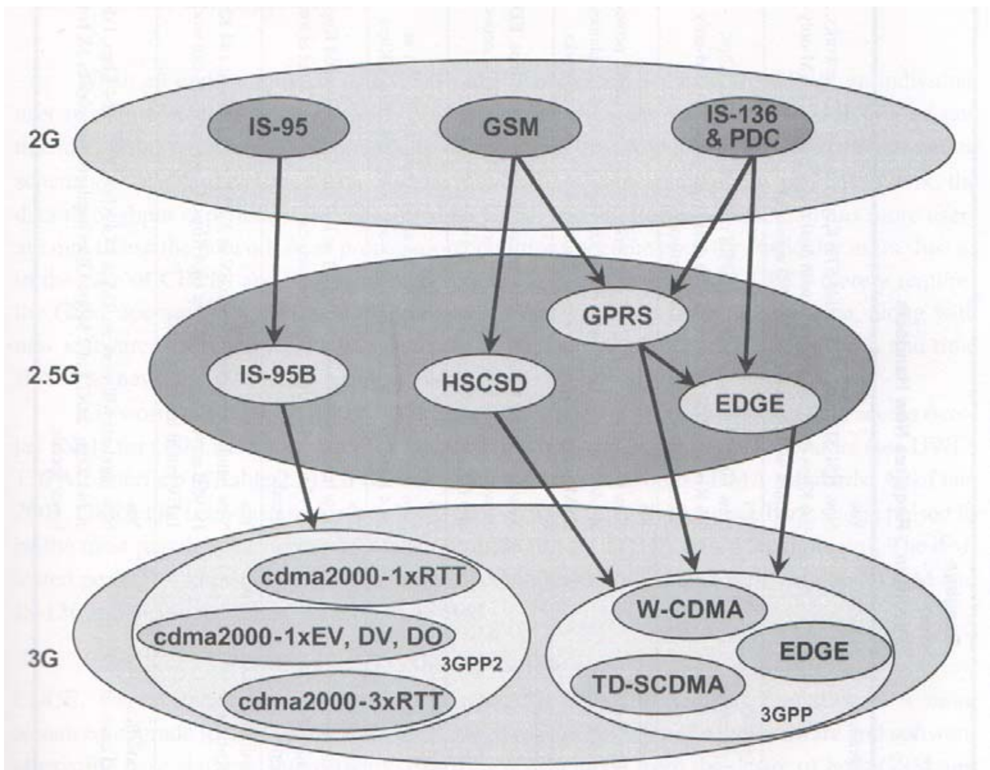

Figure 2. Upgrade paths for 2G technologies (From: Agilent Technologies)[42]

[41] Rappaport, 30.

[42] Telecommunications News, "Special Wireless Issue," Agilent Technologies, Issue 22, June 10, 2001.

1. Evolution for 2.5G TDMA Standards

Three different upgrade paths have been developed for GSM carriers, and two of these solutions also support IS-136. The three TDMA upgrade options include:

- High Speed Circuit Switched Data (HSCSD)
- General Packet Radio Service (GPRS)
- Enhanced Data Rates for GSM Evolution (EDGE)

These options provide significant improvements in Internet access speed over today's GSM and IS-136 technology and support the creation of new Internet-ready cell phones.[43] For a detailed explanation of these upgrades, the reader is directed to the reference.

2. IS-95B for 2.5G CDMA

CDMA (often called cdmaOne), and referred to in Fig. 2 as IS-95, has a single upgrade path for eventual 3G operation. The interim data solution for CDMA is called IS-95B.[44] For a detailed explanation of this upgrade, the reader is directed to the reference.

E. THIRD GENERATION (3G) CELLULAR TECHNOLOGY

In the early 1990s, the International Telecommunications Union (ITU), which is the standards body for the United Nations, developed a plan to implement a global frequency band in the 2000 MHz range that would support a single, ubiquitous wireless communication standard for all countries throughout the world.[45] This plan, called International Mobile Telecommunication 2000 (IMT-2000), is for a universal, multi-function, globally compatible digital mobile radio system that will integrate

[43] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 30.

[44] Rappaport, 34.

[45] Rappaport, 35.

paring, cordless, and cellular systems, as well as low earth orbit (LEO) satellites, into one universal mobile system.[46] The technology that will allow the implementation of this plan is known as third generation (3G). The IMT-2000 initiative has defined the ITU's view of 3G capabilities as follows:[47]

- Voice quality comparable to the public switched telephone network (PSTN)
- 144 kbps data rate available to users in high-speed motor vehicles over large areas
- 384 kbps available to pedestrians standing or moving slowly over small areas
- Support (to be phased in) for 2.048 Mbps for office use
- Symmetrical and asymmetrical data transmission rates
- Support for both packet switched and circuit switched data services
- An adaptive interface to the Internet to reflect efficiently the common asymmetry between inbound and outbound traffic
- More efficient use of available spectrum in general
- Support for a wide variety of mobile equipment
- Flexibility to allow the introduction of new services and technologies

1. Frequency Spectrum for 3G

The technical group TG 8/1 standards task group is within the ITU's Radiocommunications Sector (ITU-R). TG 8/1 analyzed worldwide frequency coordination that would allow subscriber units to work anywhere in the world. A total of 230 MHz in frequency bands 1885 to 2025 MHz and 2110 to 2200 MHz was targeted by the ITU's 1992 World Administrative Radio Conference (WARC). In March 1999,

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[46] Rappaport, 21.

[47] Stallings, W., *Wireless Communications and Networks*, Upper Saddle River, NJ: Prentice Hall, 2002: 330.

ITU-R agreed to additional spectrum allocations that included the frequency bands 806 to 960 MHz, 1710 to 2200 MHz, and 2520 to 2670 MHz. This additional spectrum allocation was approved in May 2000, at the ITU World Radio Conference (WRC-2000).[48] Spectrum allocation issues related to 3G in the United States will be discussed further in a later chapter.

2. 3G Standards

While the goal of IMT-2000 is one worldwide standard, that goal has not yet materialized. The worldwide user community remains split between GSM/IS-136/PDC and CDMA technologies. The evolution of standards from 2G to 3G reflects this split and can be seen in Figure 2, which shows the alternative 3G technology standards that have been adopted as part of IMT-2000. The ITU IMT-2000 standards organizations are currently separated into two major organizations reflecting the two 3G camps: 3GPP (3G Partnership Project for Wideband CDMA standards based on backward compatibility with GSM and IS-136/PDC) and 3GPP2 (3G Partnership Project for cdma2000 standards based on backward compatibility with IS-95).

The eventual 3G evolution for 2G CDMA systems leads to cdma2000. Several variants of CDMA 2000 are currently being developed, as shown in Figure 2, but they are all based on the fundamentals of IS-95 and IS-95B technologies. The eventual 3G evolution for GSM, IS-136 and PDC systems leads to Wideband CDMA (W-CDMA), also called Universal Mobile Telecommunications Service (UMTS). W-CDMA is based on the network fundamentals of GSM, as well as the merged

[48] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 21.

versions of GSM and IS-136 through EDGE.[49] For a detailed explanation of these standards and related current issues, the reader is directed to both the reference and GSM World (www.gsmworld.com) and the CDMA Developers Group (www.cdg.org) which provide excellent sources of 3G development information.

F. SUMMARY

This chapter has discussed the three generations of cellular technology and the five main cellular transmitting interface standards currently used in the United States. It has shown how cellular technology has evolved from primarily analog to almost purely digital. The evolution to 3G technology in the United States is taking place but at a slow rate. There are numerous reasons for this, including infrastructure modification costs, standards compatibility, interoperability, roaming, service costs, hardware costs, battery problems, and frequency spectrum inadequacy. Most of these issues are beyond the scope of this thesis. This thesis will address the frequency spectrum issue in a future chapter. Another issue not listed that will be addressed is the impact that the Telecommunications Act of 1996 has had on the evolution of 3G technology, relative to expansion.

[49] Rappaport, 35.

IV. IMPACT OF THE TELECOMMUNICATIONS ACT OF 1996 ON CELLULAR EXPANSION IN THE UNITED STATES

A. INTRODUCTION

The House of Representatives and the Senate passed the Telecommunications Act of 1996 (the Act) on February 1, 1996 by overwhelming margins. President Clinton signed the Act into law in a ceremony at the Library of Congress on February 8, 1996. The purpose of the Telecommunications Act of 1996 was "to promote competition and reduce regulation in order to secure lower prices and higher quality services for American telecommunications consumers and encourage the rapid deployment of new telecommunications technologies."[50] Whether or not the Act has accomplished the goal of promoting competition has been debated over the years since it was enacted. That argument is beyond the scope of this thesis and will not be discussed. This thesis will examine how the Act was successful in helping cellular service to expand across the United States at a phenomenal rate. This expansion has not been without difficulties and those issues will also be discussed.

This chapter will begin with an overview key provisions of the Act, in order to help the reader understand the general context. It will then examine the section of the Act that had the most dramatic effect on cellular expansion. The difficulties of this expansion will also be discussed.

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[50] Federal Communications Commission, "Telecommunications Act of 1996," 29 August 2003: 1. <http://www.fcc.gov/Reports/tcom1996.pdf>.

B. KEY PROVISIONS OF THE TELECOMMUNICATIONS ACT OF 1996

Listed below are some of the key provisions of the Telecommunications Act of 1996 and a brief summary of each. This list is not meant to be all inclusive. For a more complete explanation, as well as the full text, the reader is directed to the FCC's website, www.fcc.gov/telecom.html.

1. Telecommunications Competition

The most important part of the law dealt with the promotion of competition in local telephone services. It set out the principle that local telephone companies have the obligation to interconnect their networks with those of other competing carriers and reciprocally pass off traffic so that any customer can reach any other customer regardless of who their service providers may be.[51] Similarly, competing telephone carriers also had the right to lease circuits from the incumbents to provide services -- that is, they did not have to build their own facilities to enter the business.[52]

The law also established a range of related rules, including the requirement that competing carriers be able to offer customers the same types of telephone numbers as incumbents. The rates local incumbents charged to new carriers for these and other services were to be just, reasonable, and nondiscriminatory. The act also set out procedures for the negotiations over interconnection that would take place between telephone companies and competitors, subject to FCC and state public utilities commission (PUC) supervision. Companies also had recourse

[51] Drake, W. J. and Brodsky, A., "The Telecommunications Act of 1996, Telecommunications in an Information Age," U.S. Department of State, 29 August 2003, <http://usinfo.state.gov/products/pubs/archive/telecomm/drake2.htm>.

[52] Drake and Brodsky.

to the courts if they did not agree with the decisions of the FCC and PUCs.

Other parts of the Act prescribed rules for the development of enhanced competition in long-distance markets, to include allowing the Regional Bell Operating Companies (RBOCs) to provide long-distance services from within their traditional service areas if they met certain conditions; allowed cable television and public utility companies to provide telecommunications services for the first time; allow the RBOCs to manufacture telecommunications equipment; called on the FCC to adopt plans to move the nation toward integrated high-speed or broadband networks offering advanced digital services; required that all network operators coordinate facilities planning to ensure seamless national interconnectivity; prohibited state governments from erecting barriers to competitive entry into telecommunications markets; and required the FCC to conduct a proceeding to examine and remove any remaining barriers to market entry by entrepreneurs and small businesses.[53]

2. Cable Television and Video Services

One of the biggest issues in this area was the deregulation of the cable industry. Under the law, most cable TV services were to be deregulated on March 31, 1999, even in cases where there was no competition in the same area.[54] The Act also said that as soon as a telephone company began to offer services similar to those of a cable TV operator, then price regulation is lifted. Smaller

[53] Drake and Brodsky.

[54] Drake and Brodsky.

cable TV systems were exempted immediately from price regulation rules.

The act also prohibits a telephone company from buying out a cable company within its service area in most cases, so that one entity does not control both the telephone and cable lines to consumers' homes. However, outside the telephone companies' respective service areas, such buy-outs are deemed acceptable.[55]

Another section of the Act indicates that if phone companies want to compete with cable companies for video delivery, then they become subject to the appropriate cable system regulations. The incentive here for the phone companies is if they deliver their services via a wireless solution, then they are not subject to cable regulations. This area of the act also dealt with a technology it refers to as Open Video Systems (OVS). These OVS' were supposed to be a platform for the provision of a wider range of channels offering computer-enhanced capabilities like interactivity. The idea here was to entice the RBOCs into developing such services while simultaneously providing an open forum for the distribution of alternative news and entertainment programs that are not controlled by the system operator.[56]

3. Broadcasting

This section of the act was of particular interest to the large broadcasting companies in the United States. With regard to radio, the Act lifted all the restrictions on the number of stations the largest companies could own nationally while also putting a limit on the number that

[55] Drake and Brodsky.

[56] Drake and Brodsky.

could be owned in any one market. With regard to television, the big national TV networks, i.e. CBS, ABC, NBC, Fox, got a removal of national ownership restrictions on the number of stations one entity could own. However, while the networks' signals are carried nationwide by affiliated stations, the stations that a single company owns may reach no more than 35 percent of the national audience. The act also allows broadcasters to keep their licenses for longer periods of time without having to prove that they act in the public interest in order to obtain renewal by the FCC.[57]

Another important section in this part of the Act dealt with the licensing of the radio frequency spectrum needed to provide new digital services. To encourage the broadcasters to develop at least some free advanced television, the Act gives them preferential access to the new digital licenses. However, they also have to surrender their old licenses for reassignment to other services when they receive the new ones. Moreover, if the broadcasters use the spectrum to develop new subscription-fee services, they have to make an annual payment to the U.S. Treasury.

Also on this section was controversial part of the Act that dealt with the Congressional requirement for the broadcast industry to rate its programs for violence and sexual content. In parallel, TV manufacturers are required to build into new sets a new kind of microelectronic "V-chip" (the V stands for violence). Together, the chip and rating system allow parents to block programming deemed unsuitable for their children.

[57] Drake and Brodsky.

4. Information and the Internet

The Act established rules allowing the RBOCs to sell computerized information and electronic-publishing services, subject to certain restrictions. What is probably the most notable and controversial part of the Act is in this section and deals with information delivered over the global Internet. The Communications Decency Act portion of the Act attempted to ban the transmission of not only obscenity but also loosely defined "indecent" material. The provision's sponsor, Senator J. James Exon, a Nebraska Democrat, proposed it as a means of curbing what he saw as increasing pornography on-line. Opponents, led by civil liberties groups and many in the Internet community, said the provision violated the U.S. Constitution's guarantee of free speech by banning a type of speech that courts have ruled is protected.

On July 26, 1997, the Supreme Court struck down key portions of the Communications Decency Act in a 7-2 decision. In his written decision, Justice John Paul Stevens condemned the "vagueness" of the law, adding that that statute, as written, could have an "obvious chilling effect on free speech." He added the law had threatened "to torch a large segment of the Internet community.... In order to deny minors access to potentially harmful speech, the CDA effectively suppresses a large amount of speech that adults have a constitutional right to receive and to address to one another...."[58]

C. SECTION 704 OF THE TELECOMMUNICATIONS ACT OF 1996

Listed under Title VII—Miscellaneous Provisions of the Telecommunications Act of 1996 is Section 704. Section 704

[58] Drake and Brodsky.

directly addresses federal governmental oversight and limited preemption of local authority in cellular tower siting matters.[59] This section generally preserves local zoning authority, prohibits discrimination against different service providers, makes it illegal to pass legislation that has the effect of prohibiting personal wireless service to a community, and specifies an appeal procedure for parties alleging injury based on local governmental regulation of "personal wireless service" facility placement.[60] To properly deny a permit, a state or local government must expeditiously review requests for towers and provide a written denial supported by substantial evidence.[61] Additionally, local officials cannot base zoning regulations or denials of cell tower erection applications on the environmental effects of radio frequency emissions, if the facilities comply with the FCC regulations concerning such emissions.[62]

The FCC's stated goal with the Act was to provide better services and faster access to new technologies for consumers. The Act's chief method of accomplishing these goals was the "removal of barriers to entry" into the businesses of telecommunications services, including those provided by local, and long distance telephone companies and video, cable, and wireless companies.[63] Section 704 uses this "removal of barriers to entry" method by giving

[59] Federal Communications Commission, "Telecommunications Act of 1996,"29 August 2003: 117-118. <http://www.fcc.gov/Reports/tcom1996.pdf>.

[60] Federal Communications Commission.

[61] Federal Communications Commission.

[62] Federal Communications Commission.

[63] Federal Communications Commission, "THE HARD ROAD AHEAD -- AN AGENDA FOR THE FCC IN 1997," Dec. 26, 1996.

cellular service providers an enormous amount of leverage to get cell towers approved and built. The providers used this leverage to expand at a rapid rate. This can be clearly seen in Figure 3, which shows the number of cellular towers in the United States from 1985-2001. In the year from 1996-1997, the number of new towers nearly doubled the amount built in the previous ten years.

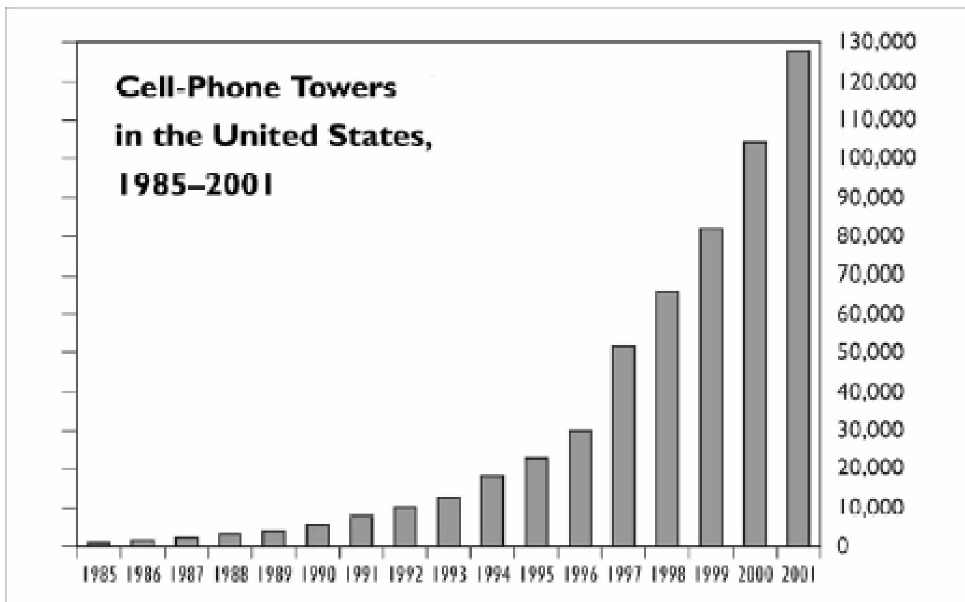

Figure 3. Cell-phone towers in the United States, 1985-2001 (From: CTIA)[64]

Cellular providers needed this ability to expand for several reasons. With an ever increasing demand for better quality cellular service, the ability to erect towers more quickly allowed the cellular providers to offer their subscribers a more continuous, better quality service. Another reason is associated with telecommunications deregulation. After the auction of frequencies for PCS by the FCC in 1995, competition increased in some areas from

[64] Cellular Telecommunications & Internet Association, 2001.

an average of two companies to over seven. In order for companies to compete, they had to be able to quickly get their towers built and begin providing service.

D. DIFFICULTIES RESULTING FROM THE RAPID EXPANSION OF CELLULAR

The rapid expansion of cellular service that occurred as a result of the Telecommunications Act of 1996 was not without difficulties. The main objections to this rapid expansion were raised by local communities and dealt with the proximity of cellular towers to residential neighborhoods. There were two primary arguments raised by concerned citizens.

The first argument dealt with the health risks associated with electromagnetic fields generated by cellular phone facilities. This argument is beyond the scope of this thesis but is one that has been hotly debated for years. According to the Food and Drug Administration (FDA), the available scientific evidence does not show that any health problems are associated with using wireless phones. There is no proof, however, that wireless phones are absolutely safe.[65]

The second argument was related to property values and the proximity of cellular towers. Homeowners were concerned that locating a cellular tower in close proximity to their property would lower their property values. Homeowners were also concerned for their own visual comfort, because of the poor aesthetics of the tower facilities. This argument is also beyond the scope of this thesis and will not be addressed.

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[65] Food and Drug Administration, "Cell Phone Facts – Consumer Information on Wireless Phones," July 29, 2003, 1 Sep 2003 <http://www.fda.gov/cellphones/qa.html#22>.

These arguments have led to a tremendous amount of litigation in the courts. Soon after the passage of the Act, communities began to issue moratoria on the building of new cellular towers as a way of preventing them from being built. These moratoria were quickly challenged in court by cellular providers. The courts have generally ruled in favor of the cellular providers but there are examples of cases that have went against them.[66]

In an effort to reduce the amount of legislation being brought into the courts over cellular tower siting, in 1997, the FCC formed the Local and State Government Advisory Committee (LSGAC), renamed to the Intergovernmental Advisory Committee (IAC) in 2003. The FCC describes the LSGAC in an unofficial announcement as providing advice and information to the Commission on key issues that concern local and state governments and communicates state and local government policy concerns regarding proposed Commission actions pursuant to the Telecommunications Act of 1996.[67] In August 1998, the LSGAC, the Cellular Telecommunications Industry Association (CTIA), the Personal Communications Industry Association (PCIA), and the American Mobile Telecommunications Industry (AMTA) entered into a multilateral Agreement in order to promulgate cellular tower siting guidelines.[68] The CTIA, PCIA, and AMTA are trade associations that represent the

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[66] Cell Slayer, "Case Studies," 1 Sep 2003 <http://www.cellslayer.com/ case.htm>.

[67] Federal Communications Commission, "Chairman William E. Kennard Announces Historic Agreement by Local and State Governments and Wireless Industries on Facilities Siting Issues," 1 Sep 2003, <http://www.fcc.gov/Bureaus/Wireless/News_Releases/1998/nrwl8032.html>.

[68] "Guidelines for Facilities Siting Implementation and Informal Dispute Resolution," 1 Sep 2003, <http://www.fcc.gov/statelocal/ agreement.html>.

wireless industry. Kenneth S. Fellman, then chair of the LSGAC, speaking in a press statement after the Agreement was reached, stated that it was "a beginning" to resolving the tensions that have arisen between local and state government leaders and cellular services providers.[69] He further claimed that the Agreement "resolves the issue of possible preemption of local zoning authority with respect to moratoria, and it gives [local and state governments] a mechanism to address the difficult issues in this area that will continue to arise from time to time."[70]

E. SUMMARY

The Telecommunications Act of 1996 was a watershed in the modern telecommunications industry. It mandated a plethora of changes in all facets of telecommunications to include competition, cable television and video services broadcasting, information and the Internet, and wireless services. Whether or not it has accomplished everything that it was intended to is still debated today. It has, however, accomplished one of its goals. The Act was instrumental in providing the newest wireless technologies to consumers as quickly as possible. Between 1996 and 1997, the number of cellular towers built in the United States nearly doubled the amount built in the ten years before 1996. This expansion provided the infrastructure for cellular providers to build digital networks offering better, more reliable service to their customers. In addition to improved service, consumers also began to see new personal communications services (PCS) networks begin to appear. Those networks have continued to evolve and

[69] Fellman, K. S., Press Statement, 5 Aug. 1998, 1 Sep 2003, <http://www.fcc.gov/statelocal/kf080598.html>

[70] Fellman.

improve as technology has improved and cellular coverage has grown.

Despite the Agreement that was reached between the LSGAC, CTIA, PCIA, and the AMTA in 1998, the same arguments raised against expansion, after the Act was passed, are still the same arguments that are used to try and block expansion today.[71] Cellular providers have even tried to camouflage their towers in an effort to make them more acceptable to local communities.[72] This appears to be an issue that will be around as long as there are cellular providers trying to expand and local communities that feel threatened.

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[71] KIROTV.com, "Seattle Mayor Seeks Ban On Cell Towers In Residential Neighborhoods - Groups Complain Towers Obstruct Views, Lower Property Values," 24 Mar 2003, 1 Sep 2003 <http://www.kirotv.com/news/2060603/detail.html>.

[72] Riviera, E., "Hidden in Plain Sight," *ABCNews.com*, 13 Dec. 2001, 1 Sep 2003, <http://abcnews.go.com/sections/scitech/TechTV/techtv_camotowers011213.html>.

V. IMPACT OF SPECTRUM ALLOCATION ON CELLULAR EVOLUTION IN THE UNITED STATES

A. INTRODUCTION

In the previous chapter, the positive impact of the Telecommunications Act of 1996 on cellular expansion within the United States was analyzed. This chapter will examine the negative impact that spectrum allocation is having on cellular evolution within the United States. Within this chapter, cellular evolution will be defined as the implementation of 3G networks and technology. The United States currently lags behind both Europe and Asia in the deployment of 3G networks and technology. Lack of available spectrum, coupled with the current spectrum management policy in the United States, are the main reasons for this.

This chapter will begin with an overview of the government organizations tasked with managing the frequency spectrum within the United States. Table 3 shows the frequency bands within the spectrum and their typical use. The next area of discussion will be a review of the spectrum management policy in the United States. The concluding topics of discussion will be the current state of spectrum allocation in the United States and how it is affecting cellular evolution in terms of technical competition and the adoption of the IMT-2000 initiative for a single, ubiquitous wireless communication standard for all countries throughout the world.

Band	Frequency Range	Free-Space Wavelength Range	Propagation Characteristics	Typical Use
ELF (extremely low frequency)	30 to 300 Hz	10,000 to 1,000 km	Ground Wave (GW)	Power line frequencies; used by some home control systems
VF (voice frequency)	300 to 3000 Hz	1,000 to 100 km	GW	Used by telephone system for analog subscriber lines
VLF (very low frequency)	3 to 30 kHz	100 to 10 km	GW; low attenuation day and night; high atmospheric noise level	Long-range navigation; submarine communication
LF (low frequency)	30 kHz to 300 kHz	10 to 1 km	GW; slightly less reliable than VLF; absorption in daytime	Long-range navigation; marine communication radio beacons
MF (medium frequency)	300 to 3000 kHz	1,000 to 100 m	GW and night Sky Wave (SW); attenuation low at night, high in day; atmospheric noise	Maritime radio; direction finding; AM broadcasting
HF (high frequency)	3 to 30 MHz	100 to 10 m	SW; quality varies with time of day, season, and frequency	Amateur radio; international broadcasting, military communication; long-distance aircraft and ship communication
VHF (very high frequency)	30 to 300 MHz	10 to 1 m	Line of Sight (LOS); scattering because of temperature inversion; cosmic noise	VHF television; FM broadcast and two-way radio; AM aircraft communication; aircraft navigational aids
UHF (ultra high frequency)	300 to 3000 MHz	100 to 10 cm	LOS; cosmic noise	UHF television; cellular telephone; radar; microwave links; personal communications systems
SHF (super high frequency)	3 to 30 GHz	10 to 1 cm	LOS; rainfall attenuation above 10 GHz; atmospheric attenuation due to oxygen and water vapor	Satellite communication; radar; terrestrial microwave links; wireless local loop
EHF (extremely high frequency)	30 to 300 GHz	10 to 1 mm	LOS; atmospheric attenuation due to oxygen and water vapor	Experimental; wireless local loop
Infrared	300 GHz to 400 THz	1 mm to 770 nm	LOS	Infrared LANs; consumer electronics applications
Visible light	400 THz to 900 THz	770 nm to 330 nm	LOS	Optical communication

Table 3. Frequency Bands (From: Stallings)[73]

[73] Stallings, W., *Wireless Communications and Networks*, Upper Saddle River, NJ: Prentice Hall, 2002: 106.

B. ORGANIZATIONS RESPONSIBLE FOR SPECTRUM MANAGEMENT

Spectrum management involves *allocation* and *assignment* of spectrum. An allocation describes use (e.g., TV broadcasting, fixed, wireless mobile phone, etc.); allocations are made internationally and domestically. An assignment authorizes an organization or entity to use a specific, discrete radio frequency channel under specified conditions.[74]

Responsibility for spectrum management in the United States is split between the President of the United States and the Federal Communications Commission (FCC). The President has delegated his authority to the Secretary of Commerce, who has delegated it in turn to the Administrator of the National Telecommunications and Information Association (NTIA).[75]

The NTIA manages the federal government's use of the spectrum while the FCC manages all other uses. The Communications Act of 1934 provides for the functions of developing classes of radio service, allocating frequency bands to the various services, and authorizing frequency use. However, the Act does not mandate specific allocations of bands for exclusive Federal or non-federal use; all such allocations stem from agreements between NTIA and the FCC. In other words, there are no statutory "Federal" or "non-federal" bands.[76]

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[74] National Telecommunications and Information Association, "Wireless Communications and Radio Spectrum Policy," 2 Sep 2003, <http://www.ntia.doc.gov/opadhome/opad_wire.html>.

[75] 10. Exec. Order No. 12,046, 3 C.F.R. 158 (1978), reprinted in 47 UNITED STATESC. § 305 app. At 127 (1989); UNITED STATES Department of Commerce, Department of Organization Orders 10-10 and 25-7.

[76] National Telecommunications and Information Association, "Who Regulates the Spectrum," 2 Sep 2003 <http://www.ntia.doc.gov /opadhome/roosa4.html>.

1. Federal Communications Commission (FCC)[77]

The FCC was established by the Communications Act of 1934 as a U.S. government agency independent of the Executive Branch and directly responsible to Congress. The FCC regulates television, radio, wire, satellite and cable in all of the 50 states and U.S. territories.

There are five Commissioners who direct the FCC. They are appointed by the President and confirmed by the Senate. Only three Commissioners can be of the same political party at any given time and none can have a financial interest in any Commission-related business. The President selects one of the Commissioners to serve as Chairperson. All Commissioners, including the Chairperson, have five-year terms, except when filling an unexpired term. Listed below are the current FCC commissioners and their political affiliation:

- Michael K. Powell – Republican - Chairman
- Kathleen Q. Abernathy - Republican
- Michael J. Capps - Democrat
- Kevin J. Martin – Republican
- Jonathan S. Adelstein - Democrat

The FCC's staff is organized by function. There are six Bureaus and 10 staff Offices. All items related to wireless communications fall under the auspices of the Wireless Telecommunications Bureau (WTB). The WTB accomplishes the following:[78]

- Develops, recommends and administers all FCC domestic wireless telecommunications programs and

[77] Federal Communications Commission, "About the FCC: A Consumer Guide to Our Organization, Functions, and Procedures," Consumer and Governmental Affairs Bureau Publication, 2 Sep 2003 <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-229127A1.pdf>.

[78] Federal Communications Commission.

policies, including cellular telephone, paging, personal communications services, public safety, and other commercial and private radio services (except those involving satellite communications or broadcasting functions);

- Is responsible for implementing the competitive bidding authority for spectrum auctions given to the Commission by the 1993 Omnibus Budget Reconciliation Act;
- Oversees spectrum auctions and handling instructional television fixed services and multipoint distribution services matters; and
- Fosters economic growth by promoting efficiency and innovation in the allocation, licensing, and use of electromagnetic spectrum.

The WTB consists of the following divisions:[79]

- Auctions and Industry Analysis Division - develops and implements policy and rulemakings necessary to conduct auctions. Responsible for developing spectrum auction procedures, scheduling and conducting auctions. Analyzes legal, economic and market data and produces the FCC's yearly Commercial Mobile Radio Services (CMRS) Competition Report.
- Commercial Wireless Division - responsible for licensing rulemakings and deregulatory matters concerning Commercial Mobile Radio Services such as Personal Communications Services (PCS), paging, Specialized Mobile Radio (SMR), and Air-to-Ground communications.
- Data Management Division - responsible for all data automation initiatives within the Bureau, including electronic filing, auto grant, public access, auction processing, network maintenance, automated and manual FCC processing, and WTB's Web site development and maintenance.
- Policy Division - proposes and develops communications rules and policies to govern wireless telecommunications services and equipment, based on major technical, economic, and regulatory developments, legislative actions, and Commission and court decisions. Monitors developments in new wireless technologies and develops long term assessments to provide a policy framework for

[79] Federal Communications Commission.

spectrum management and regulation of developing technologies.

- Public Safety and Private Wireless Division - responsible for rulemaking, regulatory and policy matters concerning public safety, industrial, land transportation, and other private mobile radio services; aviation, marine, and amateur radio services; personal radio services including interactive video and data service; microwave services including local multi-point distribution services, and certain other video and two-way services; antenna structure registration; and the radio operator program. Works with representatives of the Public Safety community to implement rulemaking and policy changes to foster a partnership to address public safety issues and implement the National Public Safety Plan.

2. National Telecommunications and Information Association (NTIA)

The NTIA was created by Reorganization Plan Number 1 (1977) and implemented with Executive order 12046 (1978). The reorganization undertaken by these documents abolished the White House's Office of Telecommunications Policy (OTP) and, by transferring most of OTP's functions to the Department of Commerce, effectively consolidated OTP with the Commerce Department's Office of Telecommunications (OT). The transferred functions included the President's authority to assign frequencies to radio stations belonging to and operated by the United States and authority to carry out other radio spectrum management activities, and long-range spectrum planning in cooperation with the Federal Communications Commission.[80]

The reorganization also transferred certain functions related to the planning and development and other aspects of the communications satellite system. Most importantly, the Executive Order made the Secretary of Commerce the

80 National Telecommunications and Information Association, "A Short History of NTIA," 2 Sep 2003, <http://www.ntia.doc.gov/opadhome /history.html>.

President's principal adviser on telecommunications policy, and transferred functions relating to studies in various areas, including telecommunications research and development and the presentation of Executive Branch views on matters to the FCC and others, to NTIA. These documents also established the position of Assistant Secretary for Communications and Information at NTIA.[81]

C. SPECTRUM MANAGEMENT POLICY IN THE UNITED STATES

Domestic U.S. spectrum policy and regulation began 90 years ago. The Radio Act of 1912 established the principle that no one could use the electromagnetic spectrum without a federal license and a series of spectrum policy principles that continue to the present. The Radio Act of 1927 established the Federal Radio Commission and set forth as its intent to "maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof."[82] The 1927 Act provided that the new Commission shall, "as public convenience, interest, or necessity requires" classify radio stations, prescribe the nature of the service, assign bands of frequencies or wave lengths and determine the power, time, and location of stations and regulate the kind of apparatus to be used.[83] Licenses were to be granted by the Commission for a limited duration (three years for broadcast licenses and five years for all others), but all federal government stations were to be assigned by the President.

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[81] National Telecommunications and Information Association.

[82] Spectrum Policy Task Force, Report - ET Docket No. 02- 135, Federal Communications Commission, November 2000, 2 Sep 2003: 7. <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf>.

[83] Spectrum Policy Task Force: 7.

Seven years later, the Communications Act of 1934 abolished the Federal Radio Commission and transferred the authority for spectrum management to the newly created Federal Communications Commission. The 1934 Act brought together the regulation of telephone, telegraph, and radio services within a single independent federal agency. The 1927 Radio Act was absorbed largely intact into Title III of the 1934 Act.[84]

From 1934 to the early 1990s, Congress enacted many amendments to Title III, but there were no fundamental changes to the core provisions that can be traced back to the 1912 and 1927 Acts. However, two noteworthy additions to the 1934 Act inserted in 1983 by Congress are section 7[85] and section 307(e)[86]. Section 7(a) establishes that it is the policy of the United States "to encourage the provision of new technologies and services to the public" and that anyone who opposes a new technology or service will have the burden of demonstrating that the proposal is inconsistent with the public interest. In addition, section 307(e) provides that the Commission, "notwithstanding any licensing requirement established in this Act," may "by rule authorize the operation of radio stations without individual licenses" in certain services.

In 1993, Congress amended Title III of the 1934 Act to authorize the Commission to assign licenses through competitive bidding.[87] The 1993 Act also required the

[84] Spectrum Policy Task Force: 8.

[85] 47 U.S.C. § 157.

[86] 47 U.S.C. § 307(e).

[87] Section 309(j) was further amended in the Balanced Budget Act of 1997. In the Open-Market Reorganization for the Betterment of International Telecommunications Act of 2000 (ORBIT Act), the Congress passed legislation excluding spectrum used for international and global

transfer of certain amounts of spectrum from federal government use to commercial use,[88] amended Section 332 of the 1934 Act with regard to the regulatory treatment of commercial and private mobile radio services, and required the Commission to collect regulatory fees from licensees and other Commission regulatees.[89]

The Telecommunications Act of 1996 added Section 336 to the 1934 Act to provide for broadcast spectrum flexibility and authority to collect certain additional fees.[90] The 1996 Act also eliminated the cap on license terms for non-broadcast licenses in Section 307(c) of the 1934 Act. In the Balanced Budget Act of 1997, Congress expanded the Commission's auction authority, provided for the transfer of additional spectrum from federal government use and granted the Commission explicit authority to allocate electromagnetic spectrum so as to provide flexibility of use.

Until recently, spectrum policy at the administrative agency level, especially at the FCC, was generally formulated on a band-by-band, service-by-service basis, typically in response to specific requests for particular service allocations or station assignments.[91] This ad hoc approach has garnered criticism over the years.[92]

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satellite services from assignment through auctions.

88 47 U.S.C. § 923.

89 47 U.S.C. § 159.

90 Federal Communications Commission, "Telecommunications Act of 1996," 29 August 2003: 63-67. <http://www.fcc.gov/Reports/tcom1996.pdf>.

91 Spectrum Policy Task Force, Report - ET Docket No. 02- 135, Federal Communications Commission, November 2000, 2 Sep 2003: 8. <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf>.

92 Spectrum Policy Task Force: 8.

It does not appear that any general spectrum management review or comprehensive planning has taken place at the FCC.[93] It was not until the 1990s that specific efforts were made to examine policies surrounding spectrum management in the United States on a more comprehensive basis. First, in December 1989, NTIA began a "Comprehensive Policy Review of Use and Management of the Radio Frequency Spectrum." This review was the first major examination of fundamental spectrum policy objectives and issues by NTIA since its organization in 1978. In 1991, NTIA issued its Report, "U.S. Spectrum Management Policy: Agenda for the Future," which made a number of significant recommendations, some of which ultimately led to legislation being enacted as part of the 1993 Budget Act.

In the 1990s, while the FCC continued with an ad hoc approach to spectrum allocations and policy, significant efforts in the area of broader spectrum policy review by the Commission took three forms: (1) implementation of competitive bidding authority; (2) en banc hearings before the full Commission; and (3) policy statements.[94]

As noted above, Congress provided the Commission authority to use competitive bidding for licensing certain classes of spectrum users and uses. While much of the implementation of these statutory changes took place on a service-by-service basis, in 1994 the Commission established the general framework for auctions across all services.[95] The Commission also completed other more

[93] Spectrum Policy Task Force: 8.

[94] Spectrum Policy Task Force: 9.

[95] Spectrum Policy Task Force: 9.

comprehensive proceedings to implement changes to Sections 332 and 309(j) of the Communications Act.[96]

In March 1996 and April 1999, the Commission held two en banc hearings on Spectrum Management.[97] Information presented at the hearings provided insight from industry and academia on their views of how the Commission's spectrum management responsibilities should evolve. Two key focus areas emerged: (1) promoting greater efficiency in spectrum use and (2) making more spectrum available. Flexibility was also emphasized for both allocations and service rules. Other key suggested initiatives included:

- negotiated interference
- new spectrum efficient technologies
- innovative and streamlined assignment mechanisms
- a more active secondary market
- more unlicensed spectrum

In November 1999, the Commission issued a Policy Statement on "Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium."[98] The Commission has also convened a Technological Advisory Committee to provide expert advice to the Commission on how to respond to rapid advances in technology, with a particular focus on spectrum management.[99]

On 13 October 2000, former President Clinton issued a presidential memorandum on the subject of Advanced Mobile

[96] Spectrum Policy Task Force: 9.

[97] Spectrum Policy Task Force: 9.

[98] Spectrum Policy Task Force: 9.

[99] Spectrum Policy Task Force: 9.

Communications/Third Generation Wireless Systems.[100] In this memorandum, he directed that the Secretary of Commerce work cooperatively with the FCC, as the agencies within the Federal Government with shared responsibility and jurisdiction for management of the radio frequency spectrum, to develop, by October 20, 2000, a plan to select spectrum for third generation wireless systems, and to issue, by November 15, 2000, an interim report on the current spectrum uses and potential for reallocation or sharing of the bands identified at WRC-2000 that could be used for third generation wireless systems, in order that the FCC can identify, in coordination with the National Telecommunications and Information Administration, spectrum by July 2001, and auction licenses to competing applicants by September 30, 2002.[101] The memorandum also directed the Secretary of Commerce to work cooperatively with the FCC to lead a government-industry effort, through a series of regular public meetings or workshops, to work cooperatively with government and industry representatives, and others in the private sector, to develop recommendations and plans for identifying spectrum for third generation wireless systems consistent with the WRC-2000 agreements, which may be implemented by the Federal Government.[102] The results of this memorandum will be discussed in the next section.

On 5 June 2003, President Bush issued a presidential memorandum on the subject of Spectrum Policy for the 21st Century.[103] This memorandum states that the existing legal

[100] Presidential Memorandum, "Advanced Mobile Communications/Third Generation Wireless Systems," 13 Oct 2000, 3 Sep 2003 < http://www.ntia.doc.gov/ntiahome/threeg/3gmemo.htm>.

[101] Presidential Memorandum, 13 Oct 2000.

[102] Presidential Memorandum, 13 Oct 2000.

[103] Presidential Memorandum, "Spectrum Policy for the 21st Century,"

and policy framework for spectrum management has not kept pace with the dramatic changes in technology and spectrum use.[104] Under the existing framework, the Government generally reviews every change in spectrum use, a process that is often slow and inflexible, and can discourage the introduction of new technology. Some spectrum users, including Government agencies, maintain that the existing spectrum process is insufficiently responsive to the need to protect current critical uses.[105] In order to improve spectrum management by the government, the memorandum issued the following directives:[106]

1. Establishment. There is established the "Spectrum Policy Initiative" (the "Initiative") that shall consist of activities to develop recommendations for improving spectrum management policies and procedures for the Federal Government and to address State, local, and private spectrum use. The Secretary of Commerce shall chair and direct the work of the Initiative. The Initiative shall consist of two courses of spectrum-related activity: (a) an interagency task force that is created by section 3 of this memorandum; and (b) a series of public meetings consistent with section 4 of this memorandum. The interagency task force and the public meetings shall be convened under the auspices of the Department of Commerce and used by the Department to develop spectrum management reform proposals.
2. Mission and Goals. The Initiative shall undertake a comprehensive review of spectrum management policies (including any relevant recommendations and findings of the study conducted pursuant to section 214 of the E-Government Act of 2002) with the objective of identifying recommendations for revising policies and procedures to promote more efficient and

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5 Jun 2003, 3 Sep 2003 <http://www.whitehouse.gov/news/releases/2003/06/20030605-4.html>.

104 Presidential Memorandum, 5 Jun 2003.

105 Presidential Memorandum, 5 Jun 2003.

106 Presidential Memorandum, 5 Jun 2003.

> beneficial use of spectrum without harmful interference to critical incumbent users. The Department of Commerce shall prepare legislative and other recommendations to:
>
> (a) facilitate a modernized and improved spectrum management system;
>
> (b) facilitate policy changes to create incentives for more efficient and beneficial use of spectrum and to provide a higher degree of predictability and certainty in the spectrum management process as it applies to incumbent users;
>
> (c) develop policy tools to streamline the deployment of new and expanded services and technologies, while preserving national security, homeland security, and public safety, and encouraging scientific research; and
>
> (d) develop means to address the critical spectrum needs of national security, homeland security, public safety, Federal transportation infrastructure, and science.

Two separate reports are due no later than 1 year from the date of this memorandum. One report will contain recommendations developed under section 3 of this memorandum by the Task Force and the other will contain recommendations developed under section 4.[107] The reader is directed to the reference for a detailed description of sections 3 and 4.

D. SPECTRUM ALLOCATION IN THE UNITED STATES

As previously stated, the Communications Act of 1934 does not mandate specific allocations of bands for exclusive Federal or non-federal use; all such allocations stem from agreements between NTIA and the FCC. The FCC handles spectrum allocation for a wide range of wireless services. This discussion will concentrate on the spectrum allocation for cellular service, PCS wireless systems and 3G wireless systems.

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[107] Presidential Memorandum, 5 Jun 2003.

1. Cellular Service[108]

When the FCC first established cellular service rules in 1983, cellular spectrum was allocated into 40 MHz of spectrum: a 20 MHz block, 825 to 845 MHz, was designated for transmissions made by mobile units, and a separate 20 MHz block, from 870 to 890 MHz, was allocated for base station transmissions. The 40 MHz allocation accommodated 666 channel pairs (a channel pair consists of a mobile frequency and a corresponding base frequency).

As shown in Table 4, cellular systems in each market area were divided into two channel blocks, Block A and Block B, each consisting of 20 MHz of spectrum. Block B licenses were initially limited to wireline carriers — common carriers that offered public landline telephone service in portions of the cellular markets that they sought to serve. Block A was limited to non-wireline cellular systems. This wireline/non-wireline distinction no longer exists.

Due to the growth in demand for cellular service, the FCC reevaluated the cellular bandplan in 1986. The FCC allocated an additional five MHz of spectrum to each cellular system, increasing the spectrum designated for each block to 25 megahertz. The additional spectrum increased the number of channel pairs in each block to 416 channel pairs. As shown in Figure 4, the frequency allocation for mobile transmissions ranging from 824 to 849 MHz, and from 869 to 894 MHz for base station transmissions.

108 Federal Communications Commission, "Cellular Services," 6 Jun 2002, 3 Sep 2003 < http://wireless.fcc.gov/services/cellular/data/bandplan.html>.

Block	Channel	Frequencies
A	Mobile	825-835 MHZ
A	Base	870-880 MHz
A*	Mobile	824-825 MHz 845-846.5 MHz
A*	Base	869-870 MHz 890-891.5 MHz
B	Mobile	835-845 MHz
B	Base	880-890 MHz
B*	Mobile	846.5-849 MHz
B*	Base	891.5-894 MHz
* Assigned in 1986		

Table 4. Cellular Bandplan (From: FCC)[109]

2. PCS Wireless Systems[110]

PCS encompasses a wide variety of mobile, portable and ancillary communications services to individuals and businesses. The FCC broadly defined PCS as mobile and fixed communications offerings that serve individuals and businesses, and can be integrated with a variety of competing networks. The spectrum allocated to PCS is divided into three major categories: broadband, narrowband, and unlicensed.

a. Broadband PCS[111]

As shown in Figure 5, Broadband PCS is allocated spectrum ranging from 1850-1910 MHz and 1930-1990 MHz. The

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109 Federal Communications Commission, "Cellular Services."

110 Federal Communications Commission, "Cellular Services."

111 Federal Communications Commission, "Broadband PCS," 6 Jun 2002, 3 Sep 2003 < http://wireless.fcc.gov/services/broadbandpcs/data/ bandplan.html>.

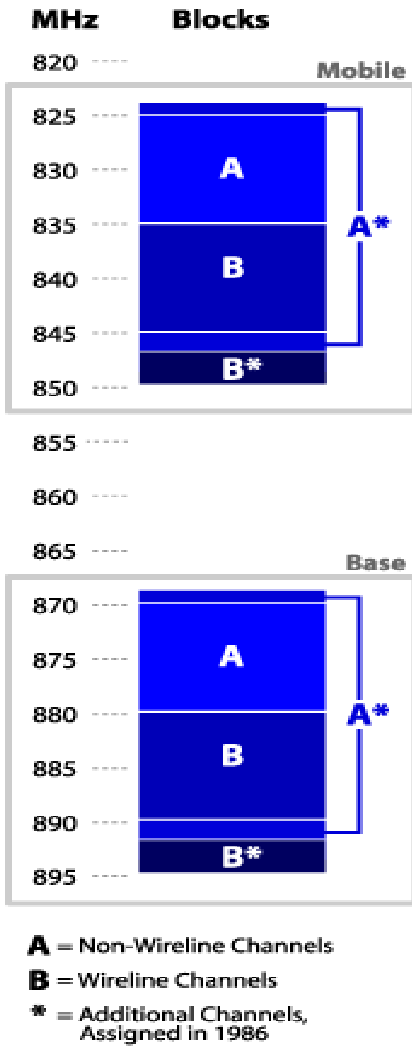

Figure 4. Cellular Bandplan (From: FCC)[112]

FCC divided this 120 MHz of spectrum into six frequency blocks A through F. Blocks A, B, and C are 30 megahertz each and blocks D, E, and F are 10 megahertz each. Some C block licenses (originally 30 MHz each) were split into multiple licenses. The splits created either C-1 or C-2 (15 MHz each) or C-3, C-4, and C-5 (10 MHz each). The C1-C5 delineation is not used for purposes of identifying the licenses.

112 Federal Communications Commission, "Cellular Services," 6 Jun 2002, 3 Sep 2003 < http://wireless.fcc.gov/services/cellular/data/bandplan.html>.

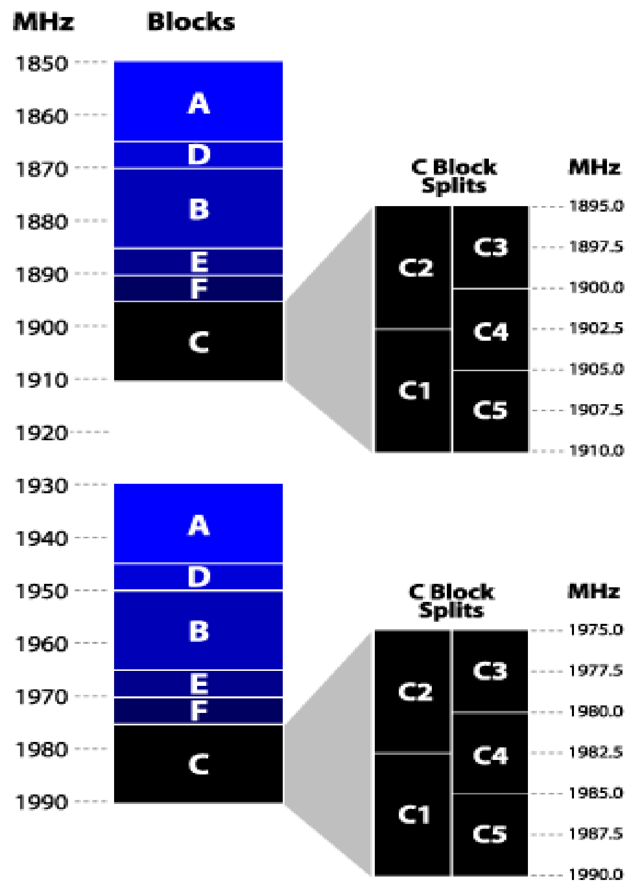

Figure 5. Broadband PCS Bandplan (From: FCC)[113]

b. Narrowband PCS[114]

Narrowband PCS uses a smaller portion of the spectrum than broadband PCS. Narrowband PCS licenses are used to provide such services as two-way paging and other text-based services. Licensees also use the spectrum to offer wireless telemetry which is the monitoring of mobile or fixed equipment in a remote location. For example, a licensee may remotely monitor utility meters of energy

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[113] Federal Communications Commission, "Broadband PCS," 6 Jun 2002, 3 Sep 2003 < http://wireless.fcc.gov/services/broadbandpcs/data/bandplan.html>.

[114] Federal Communications Commission, "Narrowband PCS," 6 Jun 2002, 3 Sep 2003 < http://wireless.fcc.gov/services/narrowbandpcs/>.

companies (this is called automatic meter reading or "AMR").

Narrowband PCS operates in the 901-902 MHz, 930-931 MHz, and 940-941 MHz bands and is licensed based on nationwide, regional, and major trading area (MTA) market designations. The rules governing narrowband PCS are found in the Code of Federal Regulations, Volume 47, Part 24. Table 4 displays the Narrowband PCS bandplan.

Channel	Frequency (MHz)	Total kHz	Licenses Awarded	Market	Auction
1	901.00 - 901.05, 940.00 - 940.05	100	1	NW	1
2	901.05 - 901.10, 940.05 - 940.10	100	1	NW	1
3	901.10 - 901.15, 940.10 - 940.15	100	1	NW	1
4	901.15 - 901.20, 940.15 - 940.20	100	1	NW	1
5	901.20 - 901.25, 940.20 - 940.25	100	1	NW	1
6	901.7500 - 901.7625, 930.40 - 930.45	62.5	1	NW	1
7	901.7625 - 901.7750, 930.45 - 930.50	62.5	1	NW	1
8	901.7750 - 901.7875, 940.75 - 940.80	62.5	1	NW	1
9	**Reserved**				
10	940.80 - 940.85	50	1	NW	1
11	940.85 - 940.90	50	1	NW	1
12	901.25 - 901.30, 940.25 - 940.30	100	5	Regional	3
13	**Reserved**				
14	901.7875 - 901.8000, 930.55 - 930.60	62.5	5	Regional	3
15	901.8000 - 901.8125, 930.60 - 930.65	62.5	5	Regional	3
16	901.8125 - 901.8250, 930.65 - 930.70	62.5	5	Regional	3
17	901.8250 - 901.8375, 930.70 - 930.75	62.5	5	Regional	3
18	940.65 - 940.75	100	1	NW	41
19(+)	901.30 - 901.35, 930.50 - 930.55	100	1	NW	41
20	901.90 - 901.95, 930.75 - 930.80	100	1	NW	41
21	901.50 - 901.55, 930.00 - 930.15	200	1	NW	41
22	901.60 - 901.65, 930.15 - 930.30	200	1	NW	41
23	901.45 - 901.50, 940.55 - 940.65	150	1	NW	41
24(+)	901.55 - 901.60, 940.30 - 940.40	150	1	NW	41
25	901.85 - 901.90, 940.45 - 940.55	150	1	NW	41
26	901.35 - 901.40	50	48	MTA	41
27	901.40 - 901.45	50	48	MTA	41
28	940.40 - 940.45	50	51	MTA	41
29	901.95 - 902.00, 930.80 - 930.85	100	49	MTA	41
30	901.65 - 901.70, 930.30 - 930.40	150	49	MTA	41
31	901.70 - 901.75, 930.85 - 931.00	200	16	MTA	41
32	901.8375 - 901.85, 940.90 - 941.00	112.5	48	MTA	41
(+) Contains spectrum from licenses that were auctioned in Auction #3 and later cancelled.					

Table 5. Narrowband PCS Bandplan (From: FCC)[115]

[115] Federal Communications Commission, "Narrowband PCS."

3. 3G Wireless

Consideration for spectrum for 3G wireless services started with the World Administrative Radio Conference (WARC) in 1992 and was further delineated at the World Radiocommunication Conference (WRC) in 2000. The quest for 3G spectrum in the U.S. began when the Federal Communications Commission (FCC) released their Spectrum Policy statement in 1999. In October 2000, the Clinton Administration directed that a plan be developed to select spectrum for 3G by October 20, 2000 that would result in the allocation of additional spectrum for 3G services by July 2001 and the auction for licensing 3G wireless providers by September 30, 2002. In December 2000, the FCC adopted a Notice of Proposed Rulemaking (ET Docket No. 00-258) to amend Part 2 of the Commission's rules to allocate spectrum below 3GHz for mobile and fixed services to support the introduction of new advanced wireless services including 3G based on the FCC's Spectrum Policy Statement and petitions from the CTIA.[116]

The Administration's and FCC's attempt to identify spectrum for 3G in 2000 and early 2001 timeframe was unsuccessful. Meanwhile, a number of countries in the rest of the world moved forward and allocated spectrum for 3G (e.g., Europe, where 155 MHz of spectrum was set aside for the 3G terrestrial component). According to the CTIA, wireless voice and data usage had grown from 16 million subscribers using 20 billion total minutes in 1993 to 130 million subscribers using 450 billion minutes in 2001. At

[116] National Telecommunications and Information Administration, "An Assessment of the Viability of Accommodating Advanced Mobile Wireless (3G) Systems in the 1710-1770 MHz and 2110-2170 MHz Bands," 23 Jul 2002, 3 Sep 2003 <http://www.ntia.doc.gov/ntiahome/threeg/va7222002/3Gva072202web.htm>.

the same time, the Department of Defense (DOD) has become much more spectrum intensive since they have had to participate in a number of defensive and offensive actions throughout the world, including Eastern Europe, Mideast, Afghanistan, and the U.S. (Homeland Defense).[117]

Secretary Evans and FCC Chairman Powell established a task force to succeed where previous efforts had failed. The NTIA in conjunction with the FCC, DOD, and other federal government agencies, studied the viability of making all or a portion of the 1710-1770 MHz and 2110-2170 MHz bands available for 3G services. This study, released in July 2002, concluded that 90 MHz of this spectrum can be allocated for 3G services to meet increasing demand for new services without disrupting communications systems critical to national security. This 90 MHz would come from the 1710-1755 MHz band and a matching 45 MHz from the 2110-2170 MHz band.[118]

a. 1710-1755 MHz Band[119]

The 1710-1755 MHz band can be used for the accommodation of advanced mobile wireless services, assuming certain actions are accomplished. Specifically, the 1710-1755 MHz band would be substantially cleared of federal systems. Except as provided below, federal users of this band would relocate or modify their operations accordingly not later than December, 2008, or sooner, depending on the nature of the radiocommunications. In order to achieve this time line, the following actions would be required:

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[117] National Telecommunications and Information Administration.

[118] National Telecommunications and Information Administration.

[119] National Telecommunications and Information Administration.

1. Reimbursement Funds: As required by the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 ("NDAA 99"), funds would be made available by the private sector entity receiving the Government spectrum (1710-1755 MHz band) for the cost of relocating or modifying all Federal Government radiocommunications systems required to vacate or modify their operations in the 1710-1755 MHz band after the auction has taken place.
2. Federal Non-Military Systems: The NTIA would direct the relocation of federal non-military systems from the 1710-1755 MHz band to other federal bands. Federal agencies that operate systems that are required to relocate under OBRA-93 are entitled to reimbursement, and would submit planning assignments to the Frequency Assignment Subcommittee (FAS) in a timely manner. Federal agencies with protected assignments have agreed voluntarily to relocate such assignments, if reimbursed, and would also submit planning assignments to the FAS. All such systems would be relocated two years after availability of reimbursed funds, or sooner if practicable.
3. Department of Defense (DOD) Fixed Microwave Systems: The DOD would relocate its conventional fixed microwave systems from the 1710-1755 MHz band to other bands within two years after reimbursement, but no later than December 2008, depending on the complexity of the relocated systems.
4. DOD's 16 Protected Sites:

a. DOD Airborne Telemetry & Video Systems: Subject to the availability of reimbursement funds, DOD would relocate their airborne operations by December 2008 to other frequency bands, such as the 1755-1850 MHz band, 2360-2385 MHz or other telemetry bands; or the 2385-2395 MHz band under primary status provided as a result of FCC rulemaking for government mobile use. The NTIA will work with DOD to facilitate the introduction of new and relocated systems into the bands identified above.

b. DOD Ground Systems: The FCC would accomplish the necessary rulemaking so that DOD ground systems in the 1710-1755 MHz band can remain on a secondary, coordinated basis at all sites, but on a primary basis at the Cherry Point, NC, and Yuma, AZ sites for operations used in a manner similar to current operations at these protected sites. DOD ground systems, other than Digital Wideband Transmission System (DWTS) operations at Cherry Point and Yuma, that cannot adjust their operations to prevent interference to commercial users in the 1710-1755 MHz band will operate in the 1755-1850 MHz band or on a non-interference, coordinated basis in the 1350-2690 MHz band. DOD ground systems may operate in the 2025-2110 MHz band on a secondary, coordinated basis in the Southwestern region of the U.S.

c. Future DOD Requirements in 1755-1850 MHz Band: Considering that DOD has future requirements to satisfy in the 1755-1850 MHz band plus the absorption of certain operations from the 1710-1755 MHz band, the FCC would conclude the necessary rulemaking by September, 2004 to permanently modify footnote US346 of the U.S. Table of Allocations to allow DOD the use of the 2025-2110 MHz band on a co-equal primary basis for DOD ground stations at selected sites that support DOD space operations. The relocation of satellite control frequencies would make more spectrum available in the 1755-1850 MHz band to satisfy future DOD spectrum requirements.

d. DOD Precision Guided Munitions (PGM) Operations: PGM operations may continue in the 1710-1720 MHz band on a primary basis until inventory is exhausted or until December 31, 2008, whichever is earlier.

e. Other DOD Systems: Other DOD systems would relocate to the 1755-1850 MHz band, or other bands as available.

5. Implementing Coordination: The NTIA, the FCC, and industry will establish a continuing process to facilitate sharing in the 1710-1755 MHz band. It is anticipated that the FCC will complete the necessary rulemakings to address the above conditions for making the band essentially clear of DOD operations at the protected sites, as well as, reallocation of

the band from government exclusive only to both government and non-government use on a mixed-use basis. It is expected that the early rollout of 3G will occur in the urban areas. Assuming reimbursed funds are available, every effort will be made to clear these areas first.

b. 1755-1770 MHz Band[120]

The 1755-1770 MHz band is not viable for use by 3G for three reasons. First, the impact to or constraints on DOD mobile radiocommunication system operations would be significant and unacceptable in light of DOD's extensive and critical operations in this band. Second, the sharing between 3G and DOD terrestrial systems in this band would not be possible in light of the large geographical separation distances required. Third, the DOD satellite ground control stations would interfere with 3G base stations at large geographical distances. In addition, it was determined that no suitable alternate federal and/or commercial spectrum could be identified for satisfactory relocation of DOD systems. A leap forward in technology may permit extensive sharing in all bands below 3 GHz in the future. Until that time, however, use of the 1755-1770 MHz band for advanced wireless applications is not considered viable.

c. 2110-2170 MHz Band[121]

According to FCC's 3G working group, 45 MHz in the 2110-2170 MHz band appears to be feasible for 3G use. It is anticipated that the FCC will initiate a rulemaking for allocation and service rules that will make 45 MHz available for advanced wireless services.

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[120] National Telecommunications and Information Administration.

[121] National Telecommunications and Information Administration.

E. SUMMARY

The frequency spectrum in the United States is managed through the cooperation of the FCC and NTIA. The NTIA manages the federal government's use of the spectrum while the FCC manages all other uses. The Communications Act of 1934, which also created the FCC, provides for the functions of developing classes of radio service, allocating frequency bands to the various services, and authorizing frequency use.

In October 2000, a presidential memorandum was issued that addressed Advanced Mobile Communications/Third Generation Wireless Systems. In this memorandum, directives were issued regarding the development of a plan to select spectrum for third generation wireless systems, and to issue, by November 15, 2000, an interim report on the current spectrum uses and potential for reallocation or sharing of the bands identified at WRC-2000 that could be used for third generation wireless systems, in order that the FCC can identify, in coordination with the National Telecommunications and Information Administration, spectrum by July 2001, and auction licenses to competing applicants by September 30, 2002. In June 2003, President Bush issued a memorandum on spectrum policy. In this memorandum, the President ordered government agencies to undertake a detailed, one-year review of their spectrum use policies, with the goal of unlocking "the economic value and entrepreneurial potential of U.S. spectrum assets."[122]

As recently as the 1990s, the FCC continued with an ad hoc approach to spectrum allocations and policy. This has

[122] Presidential Memorandum, "Spectrum Policy for the 21st Century," 5 Jun 2003, 3 Sep 2003 <http://www.whitehouse.gov/news/releases/2003/06/20030605-4.html>.

hurt the United States' ability to implement 3G networks and services. The United States has consistently lagged behind both Europe and Asia in the deployment of 3G networks and technology. Recognizing this, the previously mentioned Presidential memorandums were clearly an attempt to change the approach of the government, and the FCC in particular. The Administration has obviously recognized the importance of spectrum management and allocation to the future of 3G technology. Improving the policies and procedures of the FCC is necessary for the United States to maintain U.S. global leadership in communications technology development and services.[123]

While the overall spectrum management and allocation policies of the FCC have not been successful, i.e. the original deadlines for 3G spectrum allocation were not met; 90 MHz of suitable spectrum has been identified for 3G systems. However, it remains to be seen when that spectrum will actually be allocated. Currently, the FCC service rules for advanced wireless services are being developed. At this time, there is no date set for the auction of licenses. Subsequent to the auction, federal entities will be reimbursed for the costs incurred to relocate their radiocommunications systems from the 1710-1755 MHz band or to modify their systems. Funds for relocating federal systems from the band will be made available either directly by the private sector entities winning the auction, or via a relocation fund created from auction receipts. Legislation to authorize the use of a relocation fund mechanism is currently being considered in the House and Senate.

[123] Presidential Memorandum, 5 Jun 2003.

VI. CONCLUSION AND RECOMMENDATIONS

A. THESIS SUMMARY

From its beginnings as a way to improve public safety, cellular telephone technology has undergone an incredible transformation in the United States from both an acceptance point of view and evolutionary point of view. From 1983 to 1992, the wireless industry grew by ten million customers. This time frame coincides with the implementation of the first analog cellular network, AMPS, in 1983 to the beginnings of the shift to digital cellular networks in late 1991. From 1993 to 2000, the wireless industry grew by 90 million customers. Here again, it is easy to see that as the networks continued to improve with TDMA, CDMA, and iDEN the number of customers kept increasing. Today, there are more than 149 million U.S. wireless subscribers, As of September 7, 2003, there were 149,511,544 current United States wireless subscribers, more than 50 percent of the United States population.[124]

There are currently five different cellular transmitting interface standards that compete in the U.S. for subscribers: Analog, TDMA, GSM, CDMA and iDEN. These standards rely on bandwidth access techniques to operate, or are access techniques themselves. Specifically, FDMA, TDMA, and CDMA are the three major access techniques used to share the available bandwidth in cellular communication systems. Analog uses FDMA as an access technique while GSM and iDEN use TDMA.

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[124] Cellular Telecommunications & Internet Association Home Page, 7 September 2003 <http://www.wow-com.com/consumer/faq/articles.cfm?ID=101>.

These five standards fall under the categories of first and second generation technologies. Analog is the primary first generation technology while TDMA, GSM, CDMA and iDEN are all second generation technologies. Both first and second generation technologies are the standard technologies used in cellular systems today.

Third generation technologies are currently being developed to support the implementation of the IMT-2000 plan. This plan, developed by the ITU, is for a universal, multi-function, globally compatible digital mobile radio system that will integrate paring, cordless, and cellular systems, as well as low earth orbit (LEO) satellites, into one universal mobile system.[125] While the goal of IMT-2000 is one worldwide standard, that goal has not yet materialized. The worldwide user community remains split between GSM/IS-136/PDC and CDMA technologies. The evolution of the technologies from 2G to 3g has progressed along this split. The ITU IMT-2000 standards organizations are currently separated into two major organizations reflecting the two 3G camps: 3GPP (3G Partnership Project for Wideband CDMA standards based on backward compatibility with GSM and IS-136/PDC) and 3GPP2 (3G Partnership Project for cdma2000 standards based on backward compatibility with IS-95).

The technology being developed between 2G technology and 3G technology is known as 2.5G technology. 2.5G has come about in an effort to retrofit 2G standards, for compatibility with increased throughput data rates that are required to support modern Internet applications, before

[125] Rappaport, T.S., *Wireless Communications – Principles and Practice*, Second Edition, Upper Saddle River, NJ: Prentice Hall, 2002: 21.

the full implementation of 3G networks. The appropriate 2.5G upgrade path for a particular wireless carrier must match the original 2G technology choice made earlier by the same carrier. Therefore, 2.5G upgrades are following the same developmental path of 2G technology to 3G.

The Telecommunications Act of 1996 was a watershed in the modern telecommunications industry. It mandated a plethora of changes in all facets of telecommunications to include competition, cable television and video services broadcasting, information and the Internet, and wireless services. Whether or not it has accomplished everything that it was intended to is still debated today. It has, however, accomplished one of its goals. The Act was instrumental in providing the newest wireless technologies to consumers as quickly as possible. Between 1996 and 1997, the number of cellular towers built in the United States nearly doubled the amount built in the ten years before 1996. This expansion provided the infrastructure for cellular providers to build digital networks offering better, more reliable service to their customers. In addition to improved service, consumers also began to see new personal communications services (PCS) networks begin to appear. Those networks have continued to evolve and improve as technology has improved and cellular coverage has grown.

With the widespread and generally accepted expansion of cellular technology, there was, and still is, a significant amount of litigation in the courts trying to block the construction of cellular towers. Despite the Agreement that was reached between the LSGAC, CTIA, PCIA, and the AMTA in 1998, the same arguments raised against expansion after the Act was passed, are still the same arguments that are used to try and block expansion today.[126] Cellular providers have even tried to camouflage their towers in an effort to make them more acceptable to local communities.[127] This appears to be an issue that will be around as long as there are cellular providers trying to expand and local communities that feel threatened.

The frequency spectrum in the United States is managed through the cooperation of the FCC and NTIA. The NTIA manages the federal government's use of the spectrum while the FCC manages all other uses. The Communications Act of 1934, which also created the FCC, provides for the functions of developing classes of radio service, allocating frequency bands to the various services, and authorizing frequency use.

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[126] KIROTV.com, *Seattle Mayor Seeks Ban On Cell Towers In Residential Neighborhoods - Groups Complain Towers Obstruct Views, Lower Property Values*, 24 Mar 2003, 1 Sep 2003 <http://www.kirotv.com/news/2060603/detail.html>.

[127] Riviera, E., *Hidden in Plain Sight*, ABCNews.com, 13 Dec. 2001, 1 Sep 2003, <http://abcnews.go.com/sections/scitech/TechTV/techtv_camotowers011213.html>.

by July 2001, and auction licenses to competing applicants by September 30, 2002. In June 2003, President Bush issued a memorandum on spectrum policy. In this memorandum, the President ordered government agencies to undertake a detailed, one-year review of their spectrum use policies, with the goal of unlocking "the economic value and entrepreneurial potential of U.S. spectrum assets."[128]

As recently as the 1990s, the FCC continued with an ad hoc approach to spectrum allocations and policy. This has hurt the United States' ability to implement 3G networks and services. The United States has consistently lagged behind both Europe and Asia in the deployment of 3G networks and technology. Recognizing this, the previously mentioned Presidential memorandums were clearly an attempt to change the approach of the government, and the FCC in particular. The Administration has obviously recognized the importance of spectrum management and allocation to the future of 3G technology. Improving the policies and procedures of the FCC is necessary for the United States to maintain U.S. global leadership in communications technology development and services.[129]

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[128] Presidential Memorandum, "Spectrum Policy for the 21st Century," 5 Jun 2003, 3 Sep 2003 <http://www.whitehouse.gov/news/releases/2003/06/20030605-4.html>.

[129] Presidential Memorandum, 5 Jun 2003.

At this time, there is no date set for the auction of licenses. Subsequent to the auction, federal entities will be reimbursed for the costs incurred to relocate their radiocommunications systems from the 1710-1755 MHz band or to modify their systems. Funds for relocating federal systems from the band will be made available either directly by the private sector entities winning the auction, or via a relocation fund created from auction receipts. Legislation to authorize the use of a relocation fund mechanism is currently being considered in the House and Senate.

B. RECOMMENDATIONS

Cellular technology has expanded and evolved at a phenomenal rate since it was first developed. While technology has continued to expand, primarily due to the Telecommunications Act of 1996 and technology improvements, the evolution and implementation of the latest 3G technologies has slowed to a snail's pace in the United States. This can be directly attributed to the spectrum management and allocation policies of the government. Therefore, the following recommendations are submitted to alleviate the current situation:

1. <u>Develop a clear and coherent policy regarding spectrum management and allocation and implement it.</u>

   Perhaps the most glaring problem associated with federal spectrum management and allocation policy is the apparent lack of one. The best way for the FCC to facilitate efficient spectrum management and allocation is to have an established policy that is consistently applied in an equitable manner. The policy should do the following:

   - Identify spectrum more quickly to meet market needs.

- Have an established method for acquiring spectrum based on current ownership, i.e. buyout, auction, or reallocation.
- Efficiently allocate the spectrum.
- Promote maximum flexibility in the use of the spectrum within established parameters.
- Continue to monitor the quality of service being provided within the spectrum.
- Take necessary corrective action against organizations failing to provide the best available service to consumers.

2. Revise and streamline the procedures of the FCC.

The development of cellular technology has occurred at an exponential rate. However, the slow bureaucratic rules and outdated regulations of the FCC are inhibiting innovation and denying consumers the latest in technology and services. Steps need to be taken to revitalize the FCC and enable it to keep pace with the current speed of technology.

3. Continue to refine and improve the functioning of "secondary markets" for spectrum.

Recent rulings have authorized the establishment of "secondary markets" for spectrum. "Secondary markets" allow companies to rent out unused spectrum for short or long periods of time and are designed to promote more efficient/flexible use of existing spectrum. This situation is very similar to what the Telecommunications Act of 1996 set out to do in the wired telephone market. By continuing to refine and improve these markets, the FCC will remove a barrier to entry to the market for companies.

4. Reevaluate the requirement for auction winners to fund the cost of relocating or modifying all Federal Government radiocommunications systems required to vacate or modify their operations in the 1710-1755 MHz band after the auction has taken place.

This recommendation is specific to the 90 MHz of bandwidth that has been identified for allocation. Not only would this encourage companies to bid on the spectrum, it would also assist them in more quickly getting their technology to consumers by reducing the amount of initial capital investment.

5. Reevaluate the process of auctioning available spectrum.

Auctions have imposed high entry costs and removed any governmental responsibility for deciding which services should be offered in what regions. In this manner, spectrum auctions have suppressed the introduction of new, experimental technologies, biased the licensing process toward well-financed entities, and have presupposed that only very profitable services likely to provide a strong return on investment should be allowed. Other options for spectrum allocation should be explored, such as leasing or lotteries.

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